MARINE ENGINEERING.

Vol. 6. NEW YORK, MAY, 1901. No. 5.

LAUNCH OF THE NEW WHITE STAR STEAMSHIP CELTIC.

Another record has been broken, and the new White Star liner *Celtic,* which was launched on April 4 last, is for the moment entitled to the name, "The largest ship in the world."

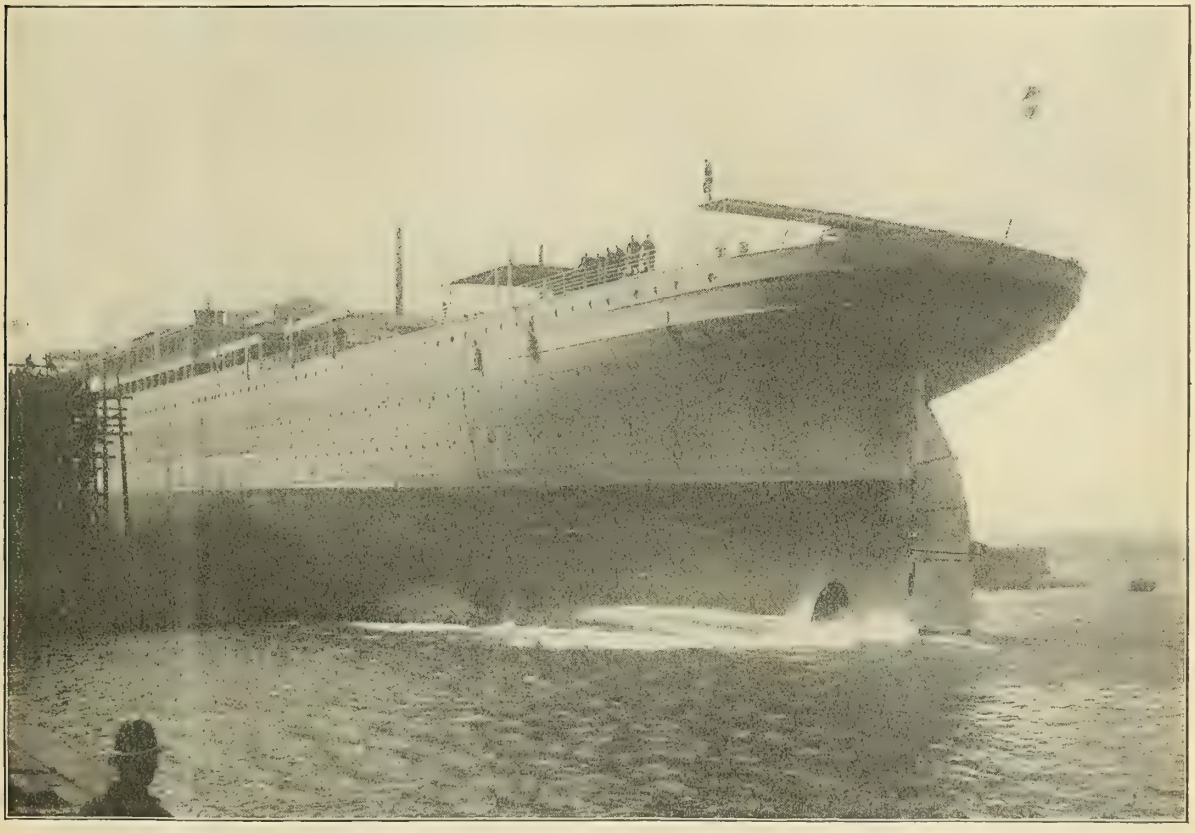
Compared with the *Oceanic* the length is about the same: the beam 7 ft. greater, the load draft some 4 ft. 6 in. greater, and the tonnage 3,000 tons greater.

The passenger accommodation is for 2,859 altogether, divided as follows: First class, 347; second class, 160; steerage or third class, 2,352. With a full complement of passengers and crew she will carry 3,294 persons—equivalent to the population of many a town of no small importance.

In point of speed the *Celtic* is to be of the intermediate type, representing a reaction from the extreme speeds which are being sought, especially by the North German Lloyd and Hamburg American lines. The speed anticipated is about 17 knots, corresponding to about eight days for the passage on the Liverpool route.

Such a ship, besides having large freight capacity, is expected to cater to the requirements of the great mass of the traveling public who regard moderate price and comfort rather than a saving of two or three days on the trip.

There is no question but that with the increase in



WHITE STAR STEAMSHIP CELTIC LEAVING THE WAYS AT HARLAND & WOLFF'S.
(Photographed for Marine Engineering by Mr. Geo. M. Roche.)

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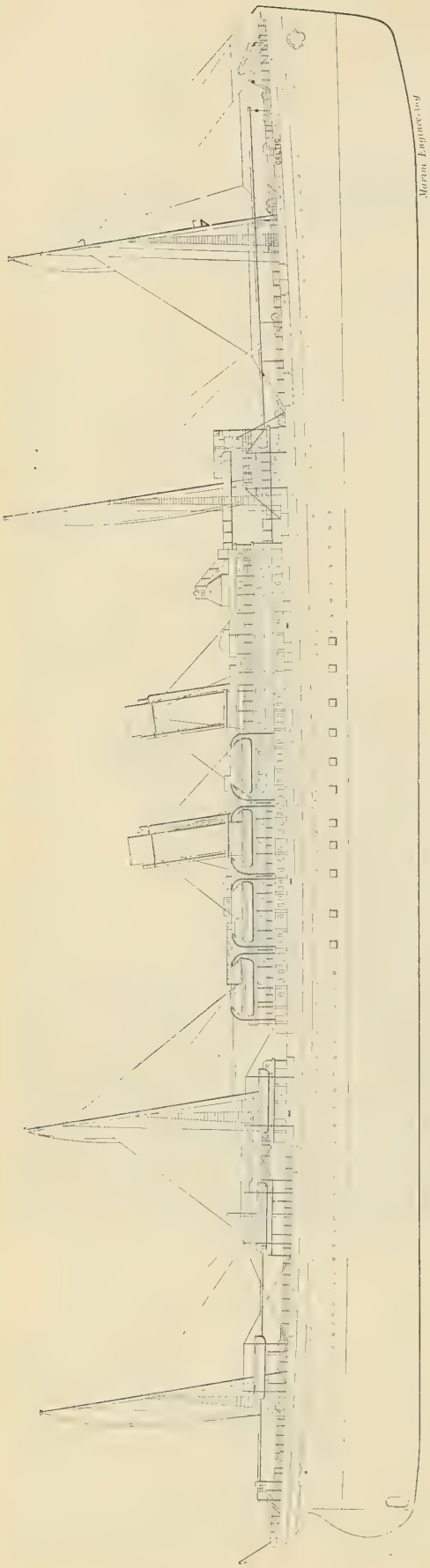
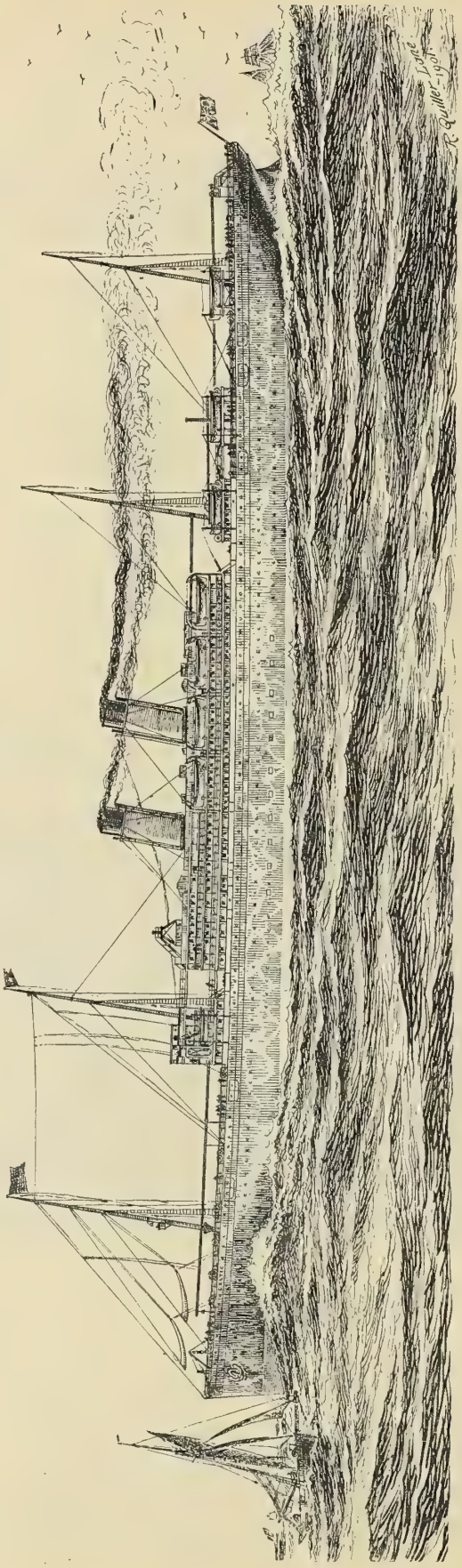


OUTBOARD PROFILE OF CELTIC.



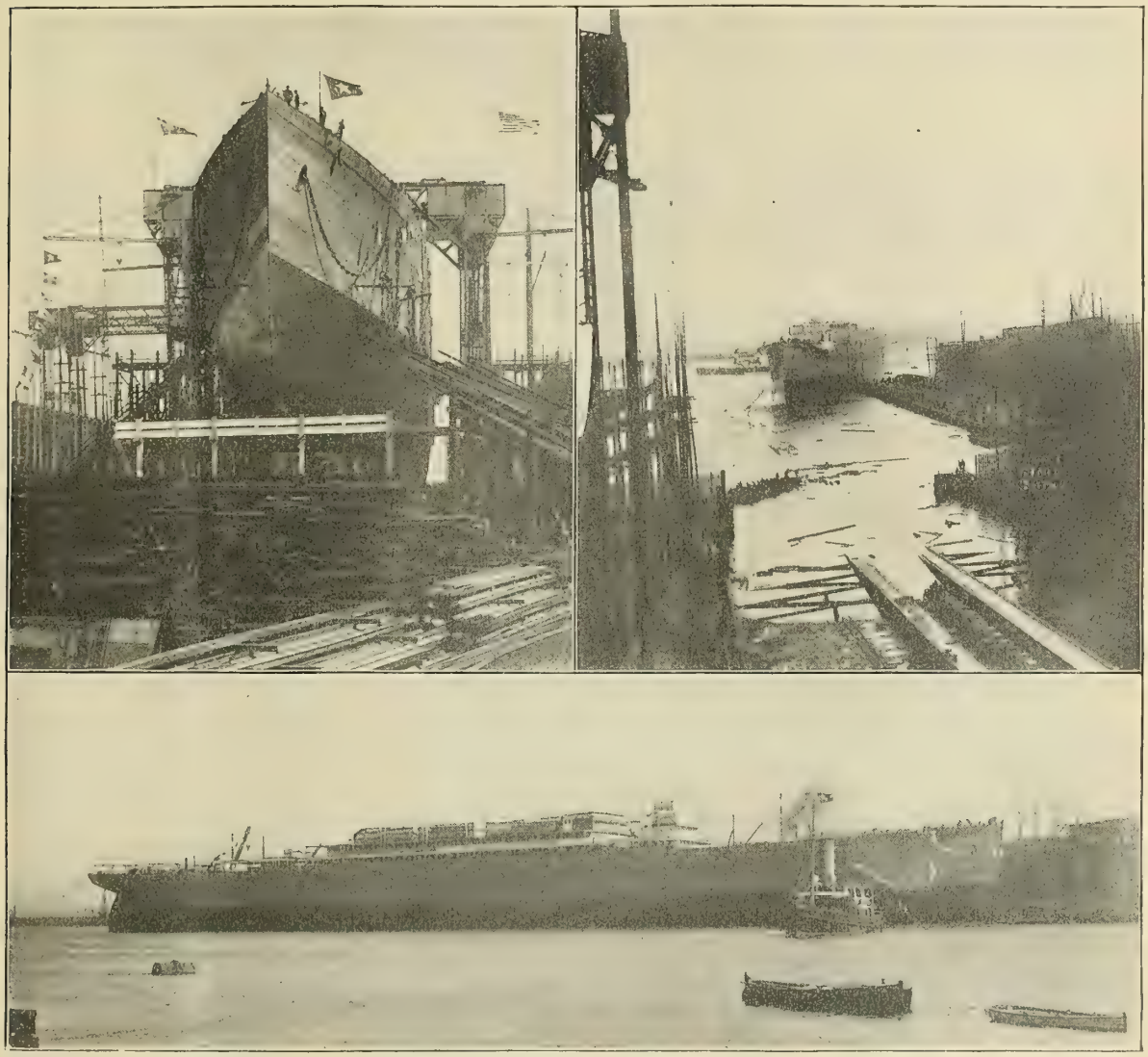
WHITE STAR STEAMSHIP CELTIC AS SHE WILL APPEAR WHEN IN COMMISSION.
(Drawn for Marine Engineering by Mr. R. Quiller Lane.)

average wealth there has come an enormous increase in the number of travelers of moderate means, to whom a few days' difference in the length of a trip is of no serious importance, and who will therefore, for moderate price, prefer such ships as the *Celtic* to the far more expensive accommodations furnished by the *Oceanic* or *Deutschland*. On the other hand, there is a part of the traveling public which wishes to go at the highest possible speed and which is willing and able to pay for the privilege. Such demand must also be met, and these facts have led in the past few years to a clearly marked difference in type in the development of modern transatlantic liners.

There will always be record breakers for speed, and where the limit in this feature will be, no one may now venture to predict. But with a different object in view, the moderate speed liner, catering to the great multitudes who will be attracted by safety, comfort and moderate price, has surely come to stay, and her further development may be watched with interest as one of the signs of the times. The *Celtic*, belonging to this type, represents the latest and largest of ocean wonders.

Put into figures the chief dimensions are as follows:

Length	700 ft.
Breadth	75 ft.
Depth	49 ft.
Load draft	30 ft. 6 in.
Displacement at load draft	37,700 tons.
Gross register tonnage	20,880 tons.
Net register tonnage	13,650 tons.

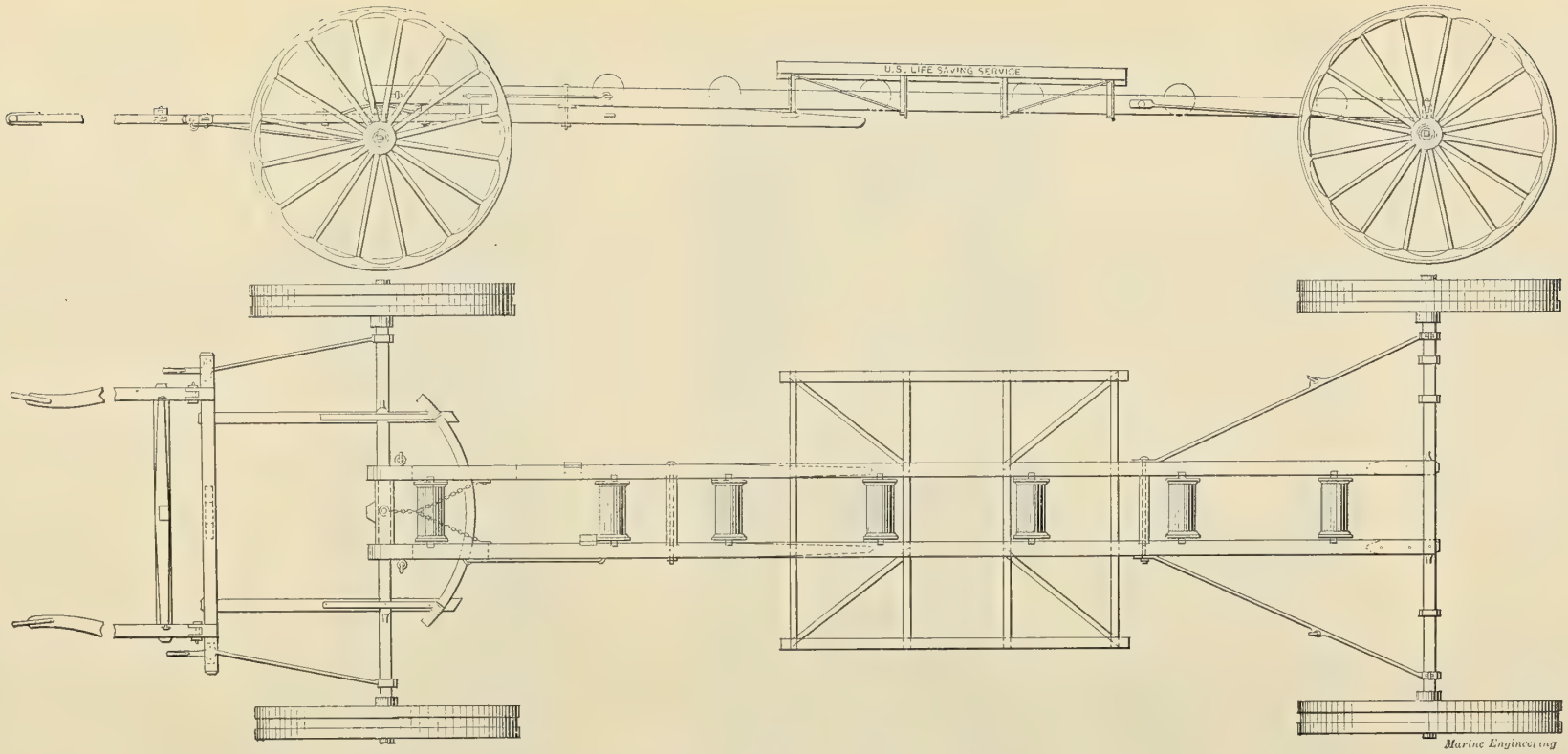


VIEWS TAKEN AT THE LAUNCHING OF S.S. CELTIC.

(Photographed for Marine Engineering by Mr. Geo. M. Roche.)

There is no reason, however, for assuming that such sizes represent a limit or even an approach to a limit, and we may expect that the near future will bring still further advances in size, advances which will displace the *Celtic* from the position which she now holds, and relegate her, perhaps before many years, to unimportant mediocrity.

The Antartic steamer *Discovery*, specially and heavily constructed of Scotch oak for Polar explorations, was recently launched at Dundee.



ELEVATION AND PLAN OF THE M'LELLAN WAGON FOR LIFE SAVING BOATS.

Life Saving Service Boat Wagon.

The boat wagon now supplied to the stations for transporting the boat to the most suitable point for going off to a wreck greatly facilitates the handling of the boat, and removes the chance of injury to the men, to which they were exposed with the wagon previously supplied.

The boat is loaded upon the wagon as follows: The forward section of the wagon is removed, and the forward end of the reach which connects the two axles brought up to the water's edge; the boat is easily run up the reach because of the rollers, and as far back over the rear axle as the wheels will allow. This leaves but a small portion of the weight of the boat to be raised when replacing the forward section of the wagon. The reach with the boat upon it is raised by the crew divided on each side, and lifting on two bars bolted under the ends of the reach pieces on each side. The bars are opened at right angles to the reach when in use, and folded under the reach at other times. After the forward section of the wagon is in place, the boat is run forward to bear evenly upon the reach, which is sufficiently elastic to permit the boat to ride easily over rough roads. To unload the boat, the reverse of the above is only necessary.

Adjustable runners are provided for each wheel, which can be quickly put on and off. Drag ropes are fitted to the wagon by which it is hauled by the crew, though at most stations horses are furnished.

A well trained crew can adjust their life-belts, place their oars across the boat, and have the boat off the wagon ready for the command "Go!" in forty-five seconds. With the old wagon a much longer time is necessary, requiring greater labor, and with danger of injury to the men.

BALANCED SECTIONAL DRY DOCK BUILT FOR THE TIETJEN & LANG CO.

HISTORICAL.

It will be necessary before going into a detailed description of the largest timber floating dry dock that has ever been constructed to glance over the past history of the docking of vessels, so that a proper understanding may be had of the conditions which have led up to this structure.

Since vessels have been built it has been necessary from time to time to remove them from the water to effect repairs and to remove marine growths from their immersed parts. In early times this was effected by beaching the vessels on a shore where there was a sufficient fall of tide to leave the vessel bare and accessible. As vessels were built of larger size this became impossible, and other means had to be found. Among these was the anchoring of a vessel securely in a sheltered place and by means of warping lines and purchase tackle bearing her over or capsizing her to such an extent that one-half of her under body and her keel were brought above water. This method was a distinct advance over the beaching of vessels, as it gave opportunity for uninterrupted work, which could be carried on without regard to the tide. The foregoing were methods that could be and were employed by the owners of vessels to repair and protect their own property.

The docking business, as such, began when commerce and shipping reached that point which required vessels so large and in such number that their repair and cleaning became a profitable investment for capital and energy. The means employed were at first crude and simple, and the present methods are the outgrowth of many years of trial and experience.

The floating dry dock is an American invention, the first patent being granted to J. Adamson, and the date, December 13, 1816, is early enough in this country's history to harmonize with the name of its inventor. This patent shows a wooden structure with a flat bottom and vertical sides, gates at one end which could be opened (when the dock was sunk) to let the vessel in and then closed, after which the water in the interior could be pumped out and the vessel repaired.

STEAMER CHESTER W. CHAPIN IN THE TIETJEN & LANG DRY DOCK.

The sectional floating dry dock seems to date from the patents of J. Thomas, December 20, 1837, number 522, and shows the first conception of distinctly separate sponsons and coupling logs, which are the essential features of a sectional dry dock. In this dock the floats or sponsons were entirely immersed, and guide frames were provided to maintain their stability while being pumped out. W. Thomas, in 1854, added side wings to the sponsons, thus making the sectional float-

ing dock complete and independent of any guides, supports or attachments to the shore. Mr. Thomas' plans show thorough and complete understanding of the problem. Each section, of which there are seven, shows independent means for pumping on each wing. There is also recognition of the principles involved in balancing a dock to prevent rolling, by dividing it longitudinally by bulkheads and arranging to pump any compartment at will. The pumps of this dock were hand pumps, and, when looking for the first application of steam power to pumping a floating dock, we find it proposed in a patent to R. Porter under date of November 14, 1835; but it is highly improbable that the Porter suggestion was ever carried out, as the arrangement seems a very impracticable one. The first application of steam power to the pumping of a sectional floating dock was by Dodge & Burgess, under their patent of October 9, 1841, and they were the first to meet and overcome the difficulty of transmitting the power between the different sections, difficult because of the constantly changing relative position of the sections. The dock of Dodge & Burgess, while sectional, was only a semi or partial floating dock, as the sponsons were entirely immersed and guided by fixed supports to maintain the equilibrium of the ship and dock.

In 1854 S. Loveland patented certain improvements in the arrangement of valves and improved the dock by a form of transverse truss, particularly adapted to distribute the strains.

The inventions noted give the outline of the growth and development of the sectional floating dock, and the dock of Thomas and Loveland of 1854, with the addition of steam pumping power remained without substantial addition or improvement until the present time.

These docks, during the period from 1840 to 1865, were extremely popular, and up to the present time one of the Dodge-Burgess docks is the largest available floating dock of this port. They were built up to eleven sections in length, or about 360 ft., and development along these lines would have continued but for the impracticability of handling any increased number of sections. The limit to the practical length of a section was found to be about 30 ft., and the extreme number that could be controlled with a reasonable degree of safety was ten or eleven, making the maximum length of the dock 330 to 360 ft.

Floating docks in one piece were built of varying sizes, but their limit in size was soon found to be less than the sectional dock, their cost more, and they possessed the very great disadvantage that it was impossible to remove them from the water for repair.

From 1845 to 1900 no addition was made to the size or capacity of the floating dock, sectional or otherwise, in this country, and the increase in length of vessels to 400, 500, 600 and finally to 700 ft., and in structural weight from 1,500 to 10,000 tons, have made impracticable the further use of docks of this character.

In July, 1891, the Tietjen & Lang Dry Dock Co. was formed for the development of the "Lang Balance Sectional Dry Dock," invented by Mr. Frederick C. Lang. In the intervening years the output has grown from a single floating dock to six, with a capacity not otherwise equaled in the country.

In January, 1898, the general proposition of building a sectional floating dry dock capable of handling vessels of 500 ft. in length and having a maximum lifting capacity of 10,000 tons was taken into serious consideration. Such a dock would have a lifting capacity about four times that of anything hitherto available about the port of New York. The general proposition was one, therefore, of great interest, and one which required careful study and investigation before actually proceeding to the work of construction. It is believed that the following description of the dock and of the special problems involved will be of interest to all who are concerned with this phase of marine engineering work.

FIG. 1—OUTLINE OF CROSS SECTIONAL ELEVATION OF DRY DOCK.

GENERAL DESCRIPTION.

The Lang Balanced Sectional dry dock, as shown in Fig. 3, is composed of five sections, each of the following dimensions: 110 ft. 10 in. wide and 80 ft. long. When coupled together they are separated by 20 in. and the section at each end has an overhang of 30 ft., making an overall length of 466 ft. 6 in. The depth at the center is 13 ft. 6 in., and at the waterways 12 ft. 6 in. The height of the wings is 39 ft. 9 in., while the available width between them is 92 ft. The draft of the dock light is approximately 4 ft. 6 in., and the maximum draft which can be lifted 26 ft., with a maximum lifting power of 10,000 tons.

PUMPING MACHINERY.

The pumping machinery consists of duplicate sets on opposite sides of the dock, each composed of two

125 horse power vertical boilers operating engines 20 in. diameter and 24 in. stroke, and making 150 rev. per min. Each engine drives a line shaft, which runs the entire length of the dock. These operate six pumps on each side of each section, or a total of 60 pumps. The pumps are 16 in. square by 20 in. stroke, and as they are driven by a reduction gear of 1 to 2 from the engine shaft, they make 75 strokes per min. This machinery is designed to pump the full capacity of the dock in 45 min.

The sections are coupled together by what are known as locking logs, which connect the sections together through keepers, as shown on the plan, Fig. 3. These logs are of oak 40 ft. long and 24 by 28 in. in section.

The essential feature embodied in the Lang Balanced Sectional Dry Dock and that which has made a floating dock of this size possible, is the subdivision of the sections into watertight compartments. The separate sections in the previous sectional dry docks were without transverse bulkheads, and any inclination of a section in a longitudinal direction would cause the water to flow towards the lower end and increase the difficulty of the unbalanced condition. In the Lang dock this has been overcome by building two transverse bulkheads in each section, and providing independent means for pumping each compartment. This results in giving to the sectional dry dock the desirable features of the present balanced dock, and at the same time retaining many desirable features of the sectional dock.

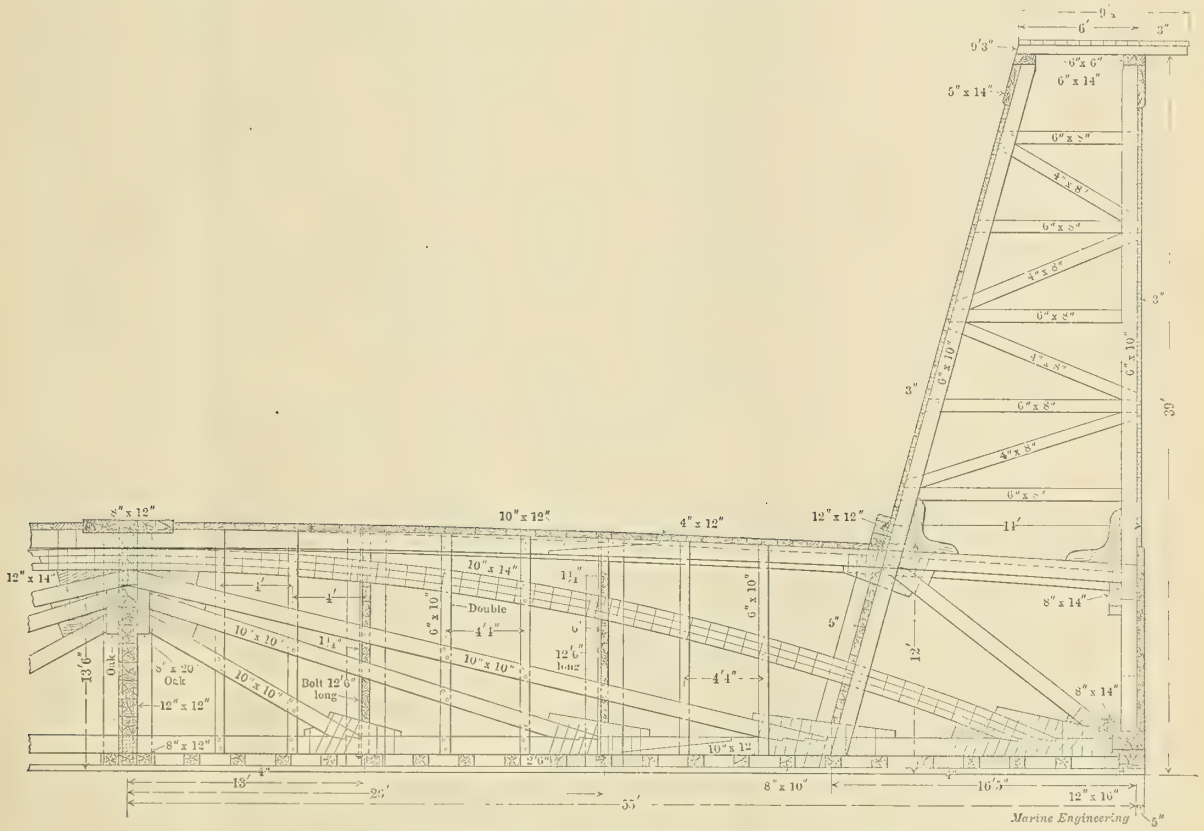


FIG. 2—CROSS SECTIONAL ELEVATION SHOWING CONSTRUCTION.

STRUCTURAL FEATURES.

Referring to Fig. 2, the main features of the truss for this dock will be seen. In the center of the dock is a bulkhead built up solid of yellow pine timber 12 in. by 12 in., and each side is divided into four panels by three longitudinal bulkheads extending from the bottom to the deck, but leaving sufficient space at the top and bottom for water communication between the compartments formed by these bulkheads and the transverse bulkheads previously mentioned. The truss proper is composed of a lower chord of 10 in. by 12 in. yellow pine timber. Three diagonals or braces of 10 in. by 10 in. timber abut at their lower ends each at the lower side of the corresponding longitudinal bulkhead. The two lower sets of braces at the center bulkhead abut against oak blocks, which were found necessary to distribute the strain to which they are subjected, without raising the compression per unit of area of the center bulkhead dangerously near the crushing point. The upper set of braces abuts at the center against each other, and the center bulkhead is cut to allow this. Above the third brace is a continuous laminated arch, composed of three yellow pine timbers, making an aggregate section of 10 in. by 14 in. This arch passes through each of the bulkheads and fits into the lower chord near each end. Above the arch and forming the deck beams is the upper member of the truss, which is 10 in. by 12 in. yellow pine timber. This member is given a crown of 1 ft., to facilitate the flow of the water from the deck, and from the intersection of this member with the inner side of each wing run diagonals of 10 in. by 10 in. timbers to the end of the lower chord. The fitting of the braces and the arch into the lower chord is reinforced by anchor stocks, which increase the sec-

tion of the members at the point where the strain is transmitted, and allow ample section for the fastenings. The arch is fastened by through bolts 3-4 in. diameter and spaced 1 ft. between centers. The fastenings of the brace are of 3-4 and 7-8 galvanized drift bolts. The center and longitudinal bulkheads are drift bolted edgeways through 2 1-2 in. planks. The floor timbers run longitudinally of the dock, and are 8 in. by 12 in. yellow pine spaced 30 in. between centers. The bottom planking is 4 in. by 12 in. yellow pine, and runs transversely or across the dock. The deck planking, which is laid longitudinally of the dock, and directly across the upper member of the truss, is of 4 in. by 10 in. yellow pine. At the center of the dock five 8 in. by 12 in. yellow pine timbers are laid to carry the keel blocks, and these are gained 2 in. over the upper member of each truss. At each side of the deck at its junction with the sloping side of the wing are two 12 in. by 12 in. timbers, called waterways. Hole stanchions or uprights are of 6 in. by 10 in. yellow pine, gaining 5 in. over all members where they intersect, and one is placed over each floor timber alternating on each side of the truss. The trusses are spaced about 37 in. between centers, or twenty-six trusses to each section. The design of these trusses, which was developed in the general solution of the problem, is found to meet in a remarkably satisfactory way the peculiar conditions under which they operate. The maximum load to which this dock can be subjected is 24 tons per running foot, or 72 tons per truss. But it is not the amount, but rather the peculiar manner in which the strains are applied that makes the problem of a suitable truss of exceptional difficulty.

MACHINERY.

The choice of machinery for this class of dry dock involved the consideration of many questions, and results were only arrived at by a series of eliminations. Fortunately a certain amount of guidance was available from previous experience in such work, and the general requirements or conditions which such machinery must meet have been already pretty well determined. Simplicity and reliability are of the first importance, and economy or efficiency, which more often heads the list in large engineering work, is here the last thing to be considered. When it is understood that the machinery at the most will be used but one or two hours in the twenty-four, and more often only once in several days, the small importance of steam economy is apparent. Therefore, in selecting the type of engine choice was made of the simple direct acting vertical type, of ample power and of great strength and solidity. In the boiler question, the type was limited to such as could be handled in the extremely limited room on the top of each wing, and the upright type with vertical tubes and submerged steam dome was considered to meet the conditions most satisfactorily. The question of pumps is one involving many considerations, and after careful examination of the ground it became apparent that the type of pump which has quite generally been used on such docks, and which the Tietjen & Lang Co. have used on their former docks, possesses qualities of simplicity and durability which cannot be excelled by more modern and apparently superior appliances. This pump is a square wooden box made of 4 in. oak planking 16 in. square inside, and about 14 ft. long, or reaching from the bottom of the dock up through the floor of the pump well a short distance above the deck. There are two of these pumps for every transverse compartment of the dock. They are single acting and each is provided with a foot valve near the bottom of the pump barrel. The foot valve and plunger are made from the same pattern, and are practically gridiron valves with a rubber diaphragm. The foot valves drop into a taper seat near the bottom of the pump barrel, and the plunger is attached to the lower end of the pump rod. The packing of the plunger is of 4 in. leather belting secured at its lower edge by rivets and free at its upper edge, to press against the pump barrel. These pumps have been found to have an exceedingly long life, and the parts to be replaced in case of wear or breakage are very simple and inexpensive. The pump rods are connected to a rocker arm, and on one end of this rocker arm is attached a connecting rod operated by a crank on the end of a shaft driven from the main line shaft. The pump rods are of 4 in. I beam, and the connecting rods of 5 in. I beam. The boxes at the upper end of the pump rod and each end of the connecting rod are of bronze and are duplicates. The crank shaft and line shaft at the point where the reduction of speed is effected are carried in two stands, and the bearings for both line shaft and countershaft are made from the same pattern, and by means of these stands the distances between centers of the gear are accurately maintained.

The object of referring to these details is to show the effort which was made to effect the greatest possible duplication of parts. In proportioning the machinery for the work to be done a large factor of safety was used, as a break in any of the machinery during the lifting of a vessel might involve a loss of much time, an item of the greatest value in the case of large vessels. The great duplication of parts makes it possible to effect any repairs quickly and with very few parts on hand.

A special problem was involved in the transmission of power from one section to another. When it is understood that a section may have a relative movement only limited by the locking log, and that this movement may be in any direction, it will be apparent that the connection must be both a universal joint and a slip coupling. A universal joint, so that the shaft may turn when out of alignment, and a slip joint so that the sections at this point may come together and separate without interfering with the transmission of power. As the slip coupling must operate under the strains of power transmission, it is necessary to provide a thrust bearing to each section. This was accomplished by securing a flanged hub to the shaft and bolting securely to the top of the dock, a cast iron plate or shoe which engages the flange of the hub and prevents longitudinal movement of the shaft. The slip joint was made of a square shaft, and all the parts of this joint and the universal joint are of cast steel.

The flood gates of the dock have an opening 12 in. square, and the closing slide is made with a taper at each side of the back, so that when forced down by a rod it will be wedged tightly against its seat. The

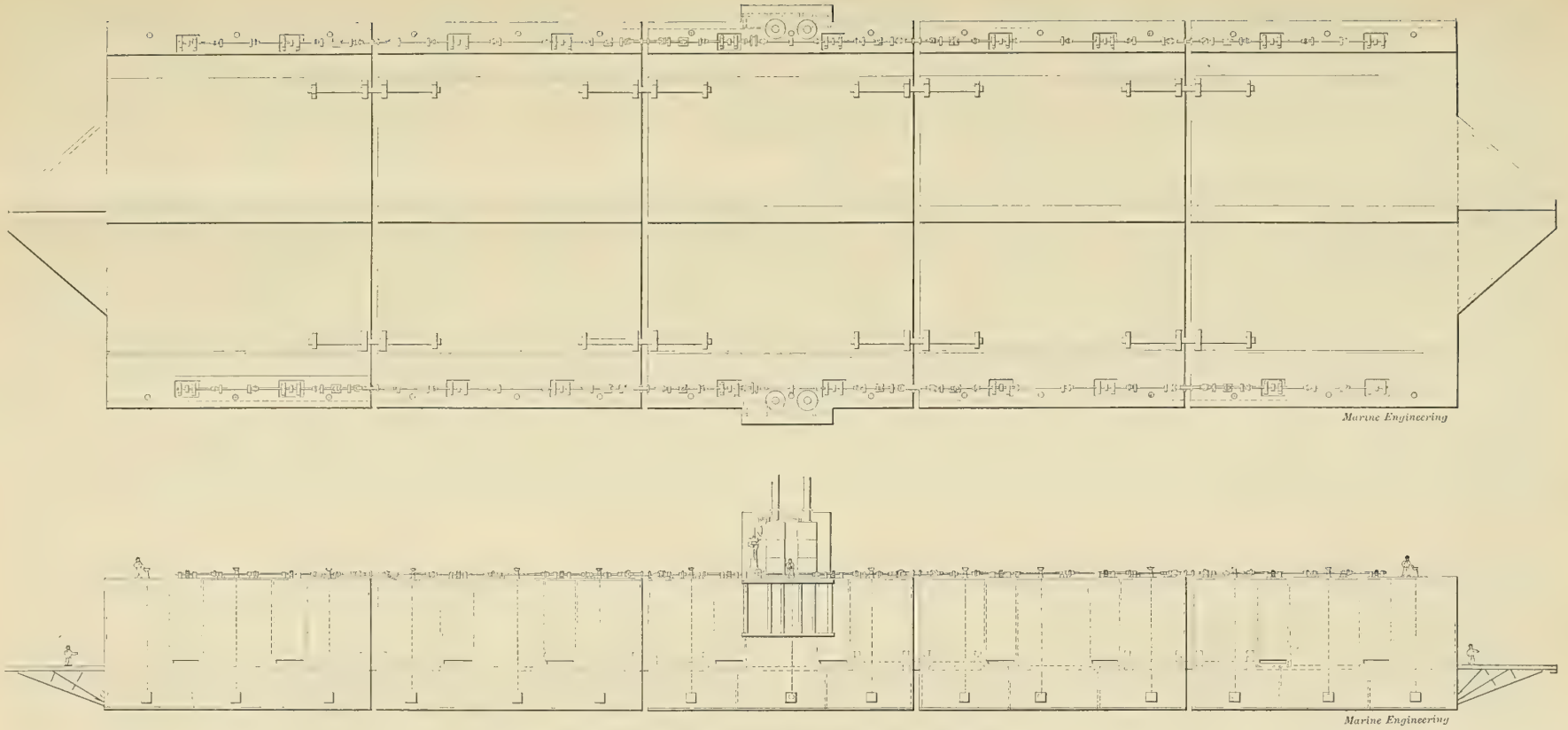


FIG. 3—PLAN AND ELEVATION OF BALANCED DRY DOCK.

operating rod runs up through the side of the wing, and the gate is raised and lowered by a wheel operating a bronze nut on the upper end of the gate rod.

In operating the dock, the engine and the pumps are running all of the time, and the desired lift to correspond to the weight of a vessel over any compartment of the dock is obtained by a greater or less closing of the flood gate corresponding to that compartment.

TRUSS PROBLEM.

Up to the present time all those who have had occasion to design trusses for this class of dock have proceeded upon the general theory that the maximum load to be borne by the truss was that due to the total weight of the ship distributed along the keel blocks at the center of the dock, and that the counter or supporting force was the distributed buoyancy over the under side or bottom of the dock, and that a truss designed to meet these conditions would be amply strong for the work to be done. Meanwhile it has been the common experience of the people handling these docks that when built with ample margin of strength to meet the conditions according to this statement of the problem, they would in a short time show unmistakable signs of weakening when subjected to their maximum

lifting power, and many attempts were made to strengthen them with but poor success.

Careful observation, extended over a long period of time, supplemented by mathematical investigation has brought out, it is believed, for the first time, the remarkable and severe conditions under which a truss of this kind must operate.

In this class of dock the wings or sides have to be built high to admit of deep draught vessels over the keel blocks, and to carry the large and heavy machinery used in pumping. Also sufficient displacement or bulk must be given to them to insure the stability of the dock and vessel. To overcome the buoyancy of the dock it is necessary to load it with stone ballast, which is placed in the wings, amounting to 5 tons per running foot, or 400 tons per section in the dock now under consideration. With these points in mind it may be seen that, starting with the dock down and a vessel over the keel blocks ready for docking, the sequence of conditions is about as follows:

1st. The interior and exterior levels of the water are about the same, as just enough ballast has been added to sink the dock to this level, and the dock is practically free from strains.

2d. The flood gates are closed and the pumps lower the interior level of the water, and the vessel is raised to a degree corresponding to the amount of water pumped out, but as the area of the wing is small relatively to the midship area of a vessel corresponding to the maximum lift of the dock, the drop of the interior level of the water will be much more rapid than the rise of the vessel and dock out of the water, and the difference will continue to increase until the wings are pumped out down to the level of the body of the dock, when it will be about 16 ft., which will correspond to a buoyancy or lifting power of 6 tons per running foot of the dock for each wing, or 18 tons for each wing per truss.

The condition of the loaded truss would now be 36 tons concentrated load at the center and a counter strain of 18 tons at points about 7 ft. from each end. With the proportions of truss here used, this would give a maximum strain at the center of the lower chord of 72 tons.

3d. From this condition there will be a rapid change, as the lowering of the water in the interior of the dock will be over its entire area, and as this is much greater than the area of the water line of the ship, especially as the immersed body of the ship decreases rapidly per foot of elevation. Consequently the difference of the interior and exterior levels of the water will rapidly grow less, the ship and dock rising much faster than the level of the interior water is lowered. This change will continue until the dock is entirely pumped out, when, if the lift has been to the maximum capacity, the dock will be just clear of the water, and the load upon it will correspond to the amount of displacement pumped out between the interior and exterior levels of the water at this time, less that necessary to float the dock at this level.

The conditions for determining the strains on the truss will now be as follows: A load at the center equal to the maximum lifting power of the dock and a counter strain or lifting force distributed evenly over the whole exterior of the bottom, just balancing the load and the structural weights for this position of the dock.

After careful investigation, the following structural weights were assigned to the dock for the length corresponding to each truss. For the body of the dock out to the commencement of the wings, 16 tons; for the structure of the wings, 8 tons; pumps and machinery, 9 tons; ballast immersed, 15 tons. The displacement immediately below this is found to be 32.4 tons. This would be sufficient to support the structural weight and ballast of this part of the dock but for the fact that the weight of the ballast heretofore given is its immersed weight, and its weight when the dock is entirely pumped out will be greater by the amount of water it displaces, which, in this case, is 300 cubic ft. or 9.6 tons. An amount of buoyancy corresponding to this must therefore be deducted from the maximum lifting power of the dock. As a result, the maximum net load which the dock will carry is borne by that part of the truss between the wings, and in calculating the strains due to the load the ends of the truss below the wings are to be disregarded. Allowing for the structural weights of the central portion (16 tons) and for the necessary freeboard to work the dock, the net lifting power will be 62.4 tons, and the strain at the center of the lower member of the truss 53 tons.

We will now consider another set of strains entirely different and of equal importance. These are brought about by the fact that it is necessary after a vessel has left the dock to pump it up light to rearrange the keel and bilge blocks. The pumping required to do this will be only that which will be necessary to bring the deck or floor of the dock above water. This will require the elevation of the dock to the same height as at the previous pumping, but the conditions will be very different. We shall have the same structural weights distributed in the same manner, but the weight which the dock previously supported will now be represented by water within the interior, and the difference of level between the water within the dock and on the outside will be that necessary to establish an equilibrium between the weight of the structure above water and the weight of the ballast less the buoyancy of the submerged wood.

In such case the difference in interior and exterior levels is found to be 3 ft., which corresponds to an upward thrust of 32 tons evenly distributed over the entire lower surface of the portion of the dock we are considering. But the structural weights and ballast are arranged very differently; the center portion between the wings contains no ballast and has a buoyancy, due to the material of its construction, of about 8 tons, while the wings are of such weight, including the ballast and machinery, that they require the entire displacement of the portion of the dock below them to support their weight.

Therefore, under such conditions, there is an upward thrust or force of 32 tons distributed over the entire bottom, due to the difference of interior and exterior levels of water, together with an additional upward thrust of 8 tons distributed over the part containing no ballast, and a weight or downward thrust on the wings to counteract this.

To state this plainly and in its simplest terms, there

is at this time a force tending to break the truss in the reverse direction to those hitherto considered. This strain amounts to 40 tons tensile at the center of the continuous arched member, and this is the condition which it is designed to meet.

TIMBERING AND FASTENING.

Besides these conditions there is the important fact that the whole structure must be made and maintained watertight, or else the strength and integrity of the structure will be of no value for the purposes intended. It will be noticed that the bottom planking runs transversely of the dock, and the deck planking longitudinally or at right angles. These are important features, first introduced in this dock, their value being that, as the lifting strain is applied, the tendency is to compress the deck planking and compress the seams, and that there is no tendency to open the bottom seams, as there would be if the planking, as heretofore, was placed directly upon the lower members of the truss in a longitudinal direction. We might say here that the calculations for the strength of the truss were based on the material in the truss proper, although it is very apparent that the planking, as here used, will add greatly to its strength. The outer corner of the sections where the lower members of the truss terminate is difficult to maintain, and it is believed that the arrangement here used, in which the end of each lower chord has been dovetailed into the top of the corner log and into the bottom of the bilge log above it, is the best practical sclution of the problem that has yet been obtained. The outer uprights for the wings are each 6 in. by 10 in. yellow pine, and are dovetailed into the outer side of the bilge log and through bolted to the 8 in. by 14 in. capping log, which is securely cross bolted down through the end of each lower truss member and through the bilge log. The uprights for the sloping side of the wing are of 6 in. by 10 in. timber, and run by the truss members and are cross bolted to them at the intersection. Braces and diagonals of 6 in. by 8 in. yellow pine timber are worked in the wing to receive the compression strains, and their vertical spacing is proportioned to meet these conditions.

As the length of the lower and upper chord members of the truss is greater than could be obtained in single lengths of yellow pine timber, it was necessary to go very carefully into the matter of scarfing or splicing. The brakes were so arranged that they repeated or occurred at the same distance from the end of the truss, on every fifth truss for the bottom chord, and on every fourth truss for the upper chord. Each scarf was then through bolted with screw bolts, and side splices of 4 in. by 12 in. yellow pine were drift bolted to each side of the lower chord members, and on one side of the upper chord members. The butts in all bulkheads were scarfed, and scarfing plans were laid out so that the butts were distributed to insure the greatest strength. Plans were made showing the planking of the main dock, side of wings, and bottom, and the lengths of strakes were laid off, and all the butts carefully distributed so that the greatest variety in lengths of planking could be used and the best distribution of butts obtained. The bottom planking repeated brakes every eight strakes, as did also that for the sides of the wings and the main deck planking. From these detailed plans the length and dimensions of each piece were obtained, and it was possible to make a bill of lumber that was accurate and complete for the material of one section, and this bill was used in getting out the lumber in the South by the lumber mills in precisely the same way as a bill of material is used by the rolling mills for structural iron.

LAUNCHES—HOME AND FOREIGN

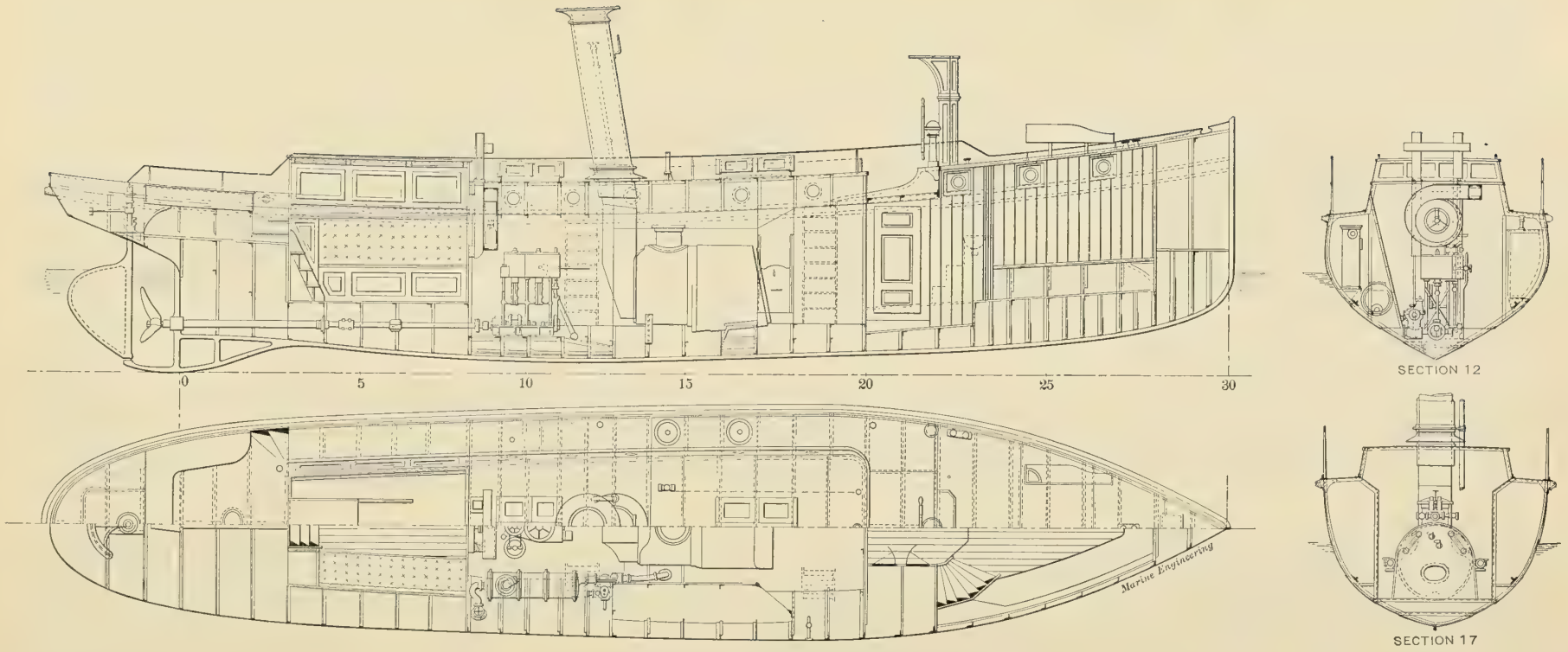
S.S. KENNEBEC.—The new steel steamer *Kennebec*, for Chesbrough Bros., of Bay City, Mich., was launched from the yard of the Jenks Shipbuilding Co., Port Huron, Mich. She is 257 ft. long, 43 ft. beam, 26 ft. depth. Her capacity is 3,000 tons.

EXCURSION STEAMER.—The new steel excursion steamer which George Moon, of Buffalo, N. Y., was building for service on the Niagara River and about Buffalo, was recently launched. The vessel is 80 ft. long, 17 ft. beam and 5 ft. draft, and the engine will be furnished by Sutton Bros.

S.S. WILLIAM L. BROWN.—The new lake freight steamer, *William L. Brown*, was launched from the yard of the Chicago Shipbuilding Company, South Chicago, Ill., recently. She will be used for the carrying of ore, and is of the following dimensions: Length over all, 450 ft.; beam, 50 ft.; moulded depth, 28 1-2 ft. The *Brown* will go into commission about the middle of April.

S.S. APACHE.—The new passenger and freight steamship *Apache*, which was built for the Clyde Steamship Company, of New York, was successfully launched at the Cramp shipyard last month. The new vessels, which will be used in the New York and Jacksonville service of the line, is of the following dimensions: Length, 310 ft.; beam, 46 ft.; depth of hold, 31 ft. She will have a capacity of 3,000 tons of cargo, and will be fitted with triple expansion engines capable of 2,500 horse power. Her boilers are of the single ended return tube cylindrical marine type. The speed will be 15 knots. There will be modern accommodations for over 200 passengers.

S.S. DENVER.—The new steel freight and passenger steamer *Denver* was launched at the yard of the Harlan & Hollingsworth Company, Wilmington, Del., on April 4 last. The vessel is for the Mallory Line, and will run between New York, Galveston and other Southern ports. She will be the largest vessel of her class in the United States, and on 19 ft. draft will carry 3,000 gross tons. She will be handsomely fitted with every convenience for comfort and pleasure, and will have a speed of 16 1-2 knots. She will be fitted with direct acting triple expansion engines with cylinders 33 1-2 in., 54 in. and 87 in. by 54 in. stroke. Steam will be supplied by four cylindrical boilers, 16 ft. 3 in. dia. by 11 ft. 6 in. long and with a working pressure of 180 lb. per sq. in. The Japanese custom of releasing doves was carried out instead of the customary breaking of a bottle of wine over the bow. The dimensions of the *Denver* are: Length over all, 386 ft.; beam moulded, 48 ft.; depth to main deck moulded, 26 ft. She is of the awning deck type of ocean steamer, with three decks running from stem to stern. There will be accommodations for 58 first class passengers and 78 steerage passengers.



STEAM PINNACE BUILT FOR THE IMPERIAL GERMAN NAVY.

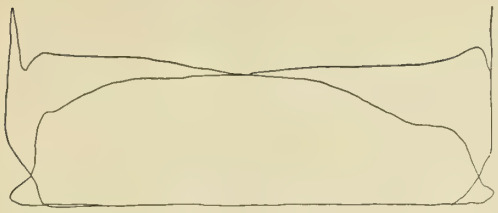
STEAM CUTTER CONSTRUCTED BY THE FIRM SACHSENBERG BROS., ROSSLAU ON THE ELBE.*

The firm of Sachsenberg Bros., of Rosslau on the Elbe, has recently delivered to the Imperial Dockyard at Kiel a Steam Pinnace of which the inboard profile, deck plans and sections are shown in the accompanying drawings. The boat is intended to be seaworthy for the waters about Kiel, and is provided with arrangements for towing other craft. The chief dimensions are as follows: Length, 47.6 ft.; beam, 10.4 ft.; depth, 6.5 ft.; draft, 4.6 ft., with complete equipment and three tons of coal on board. The boat is divided by four watertight bulkheads into five compartments. The material for the hull is of the best German Siemens-Martin steel. With regard to the subdivision of the internal space and the general arrangements the following points may be noted: In the stern is found an enclosed cabin with the necessary accommodations for eight persons. Adjoining aft is found an open room provided with seats about the sides. Amidships is found a single compartment for boiler, main engine and machinery equipment, while forward of this are found enclosed quarters for the crew provided with stowage room for clothing and provisions.

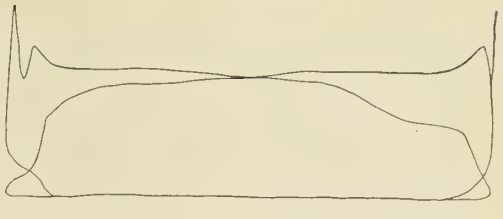
The main engine is of the compound condensing type, with principal dimensions as follows: Diameter of H. P. cylinder, 5.3 in.; diameter of L. P. cylinder, 13.8 in.; stroke, 7.9 in.

The engine with steam at 154 lb. per sq. in. boiler pressure, and 350 rev. per min. develops normally

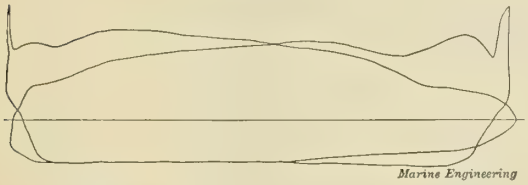
*Reprinted from *Schiffbau*, No. 8, 1901.



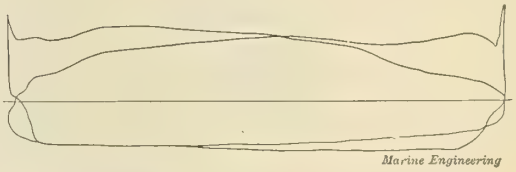
Revolutions - - - - - 344
I. H. P. - - - - - - 42.6



Revolutions - - - - - 336
I. H. P. - - - - - - 38.9

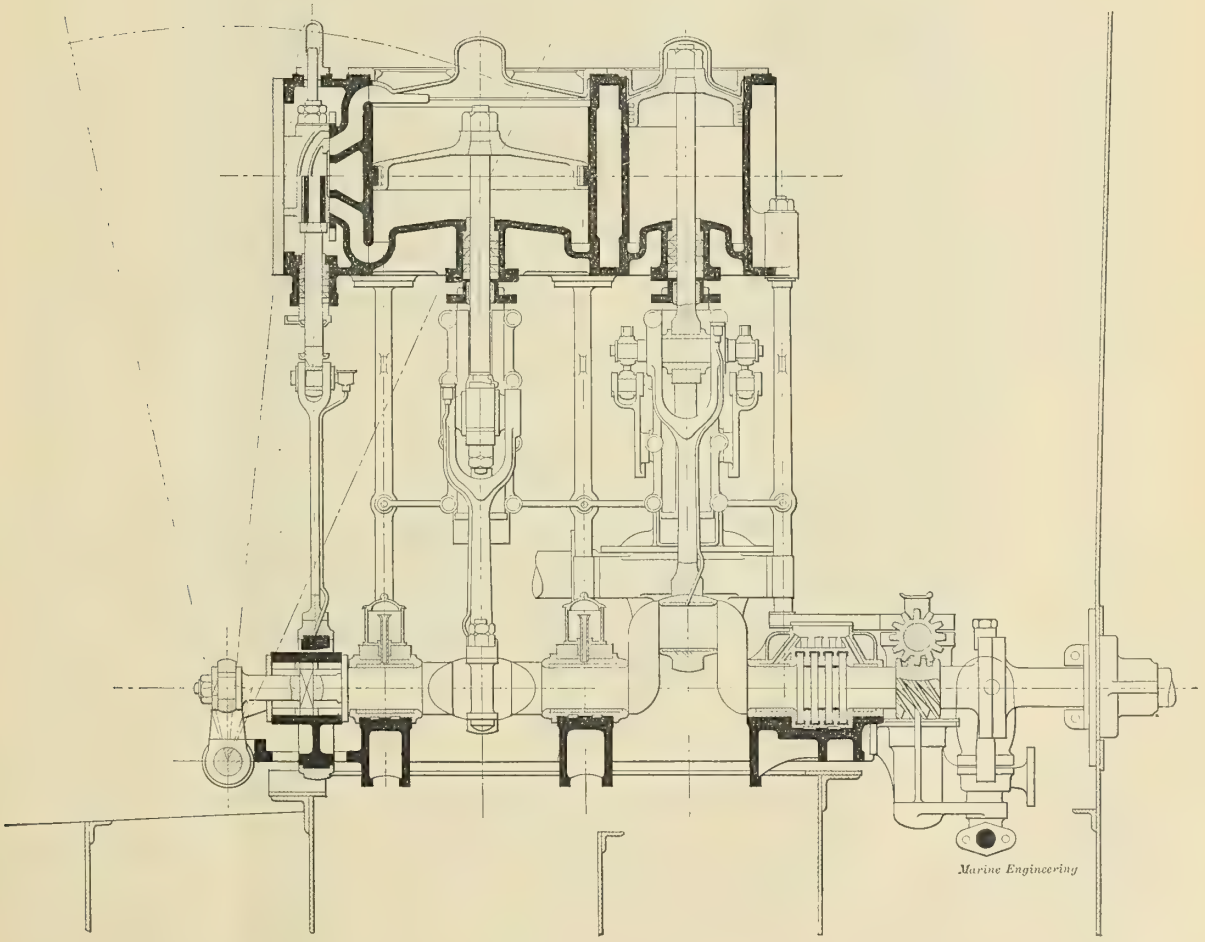


Revolutions - - - - - 354
I. H. P. - - - - - - 39.9



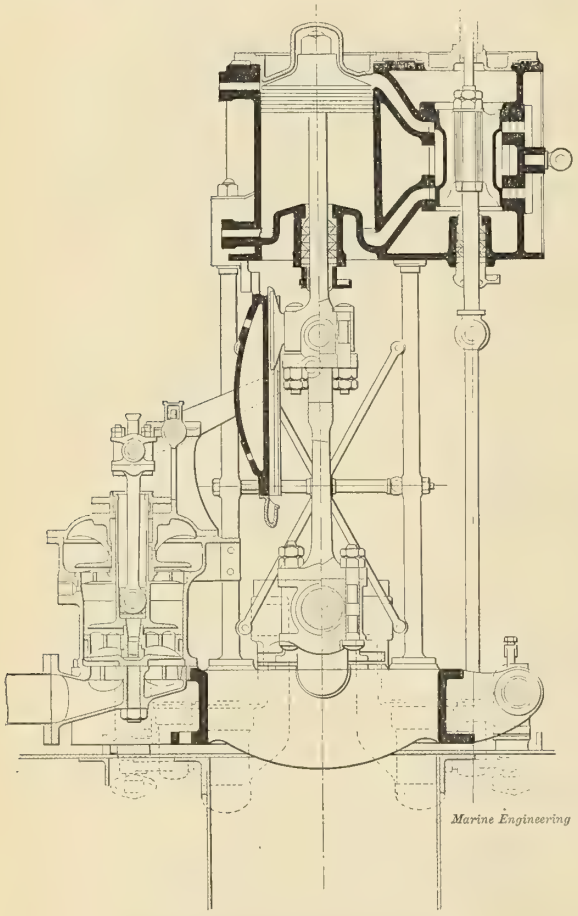
Revolutions - - - - - 336
I. H. P. - - - - - - 35

TWO SETS OF INDICATOR CARDS TAKEN FROM GERMAN PINNACE ENGINE.



SECTIONAL ELEVATION OF GERMAN PINNACE ENGINE.

75 I. H. P. The maximum power under about 370 rev. is 100 I. H. P. The maximum piston speed is about 470 ft. per min. The two cylinders with their barrels and valve chests are of cast iron and are in one piece. There is no special provision for drying or superheating the steam, and only the low pressure cylinder is provided with a steam jacket, which takes its steam from the high pressure exhaust. The two pistons are of cast steel while the cylinder covers are of bronze. The cylinders rest upon six cylindrical columns, which are bound together through transverse and diagonal members. Of the three main pillow blocks the after



END ELEVATOR OF PINNACE ENGINE.

one is provided as a thrust bearing. Of special note in connection with this design is the simplicity of the valve gear, a feature so desirable with small engines. The single eccentric gives motion at the same time to the piston valve for the H. P. cylinder and to the slide valve with "Trick" ports, with which the L. P. cylinder is provided. The main condenser is of copper and is independent of the engine frame. The cooling water is put in circulation by a centrifugal pump, which is operated by a small single acting, direct connected steam engine.

The air pump, which is entirely of bronze, is operated by an arm from the cross head of the high pressure cylinder. Two feed pumps and a bilge pump derive their motion by worm gearing from the main shaft. For the development of the necessary steam a locomotive boiler is provided with 236 sq. ft. heating surface. The firing is from forward, and the necessary draft is provided by a blast from a fan operated by the main engine.

In the way of additional equipment a steam pump, an ejector, a feed water tank and also a fresh water tank are provided.

The screw propeller is of three blades, with a diameter of 3.28 ft. and a pitch of 3.94 ft.

On the trial trip the Pinnace maintained the guaranteed speed of 10 knots. The accompanying table shows the various features of the measured mile trials which were carried out near Kiel on August 1, 1900. The four indicator diagrams shown in the accompanying figures were also taken at the time of these trials.

MEASURED MILE TRIALS OF GERMAN PINNACE.
KIEL, AUG. 1, 1900.

Number of Run.	Time on Course.		Revolutions Per Minute.	Mean Effective Pressure.		Indicated Horse Power.			Speed in Knots.	Percentage of Propeller Slip.	Air Pressure in Fireroom—Inches of Water.
	Min	Sec.		H.P.	L.P.	H. P.	L. P.	Total			
1	6	5	344	73.9	19.3	42.6	39.9	82.5	9.863	26.2	.4—.5
2	6	24	336	69.3	17.3	38.9	35.	73.9	9.375	28.2	.4—.5
Average Values.	6	14½	340	71.6	18.3	40.75	34.75	78.2	9.619	27.2	.4—.5

THE navy estimates of Great Britain for the year 1901-1902 amount to about $150,000,000, being an increase of $10,000,000 over the amount appropriated this year.

A COMMITTEE will be appointed to investigate the subject of establishing a naval station and dockyard at Olongapo, Subig Bay, P. I. The lack of docking facilities in the Far East has been keenly felt during the China troubles.

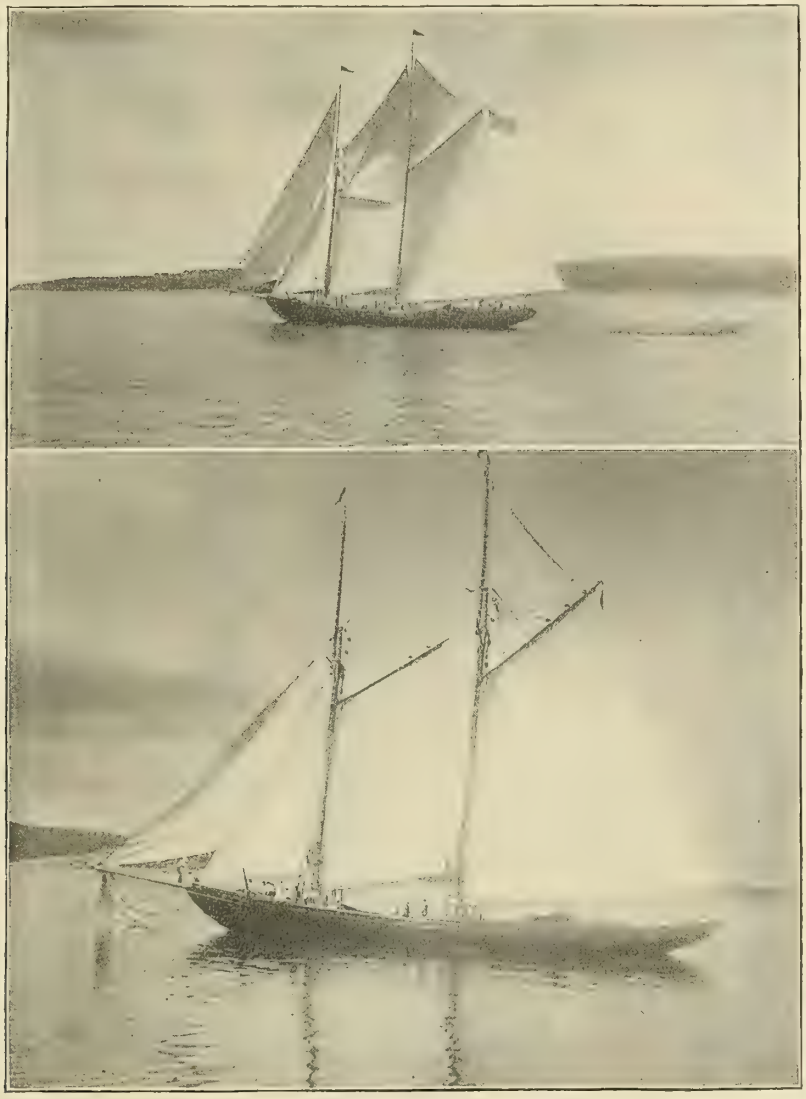
A SUM of $34,000,000 was recently appropriated by the French Government for carrying out a vast work of improvement, such as deepening the anchorages in home waters and protecting them against torpedo attacks, organizing torpedo stations, enlarging the dry docks, creating vast depots of coal and war stores and providing bases of operation in different parts of the world.

A 14 PER CENT dividend has been declared by the directors of the Holland-American Line. The passenger traffic on the New York line has been very heavy during the last year. The freight service on the Norfolk route has increased to such an extent that orders for three 8,000 ton cargo ships have been placed with Messrs. Furness, Withy & Co., of West Hartlepool.

THE *Kronprinz Wilhelm,* of the North German Lloyd Co., was launched at Stettin on March 30. Her principal dimensions are: Length over all, 663 ft. 4 in.; beam, 66 ft.; depth, 43 ft.; gross tons, 14,800; draft (normal), 28 ft. 6 in.; corresponding displacement, 21,280 tons. The two quadruple expansion engines, balanced by the Schlick system, will indicate 30,000 H. P. Steam at 225 lb. pressure will be supplied by twelve double ended and four single ended boilers, with a total heating surface of 93,649 sq. ft. and a grate surface of 2,691 sq. ft. The guaranteed speed is 22 knots. There are accommodations for 600 first cabin, 350 second cabin and 700 third cabin passengers. The crew will number 525 men.

FISHING SCHOONER "ROB ROY" SAILING OUT OF GLOUCESTER, MASS.

In smaller wood construction, a very pretty example of the skill of the naval architect, applied to a merchant vessel, is shown in the accompanying drawings of the new fishing schooner *Rob Roy*. When in the water this boat might easily be mistaken for a pleasure yacht, especially as it has the modern spoon bow, considerable overhang at the stern, and beautifully



CROWNINSHIELD DESIGNS OF FISHING SCHOONER.

white and well fitted sails. The *Rob Roy* was designed by B. B. Crowninshield, naval architect, of Boston, Mass., for George Steele, of Gloucester,, Mass., and was built at the yard of A. D. Story, Essex, Mass.

In planning this vessel, the owners decided that they would not employ rule of thumb methods, but would call to their aid the skill of the naval architect, and as a result they have now one of the finest fishing vessels afloat; a vessel which for speed, stability and carrying capacity is an acknowledged success.

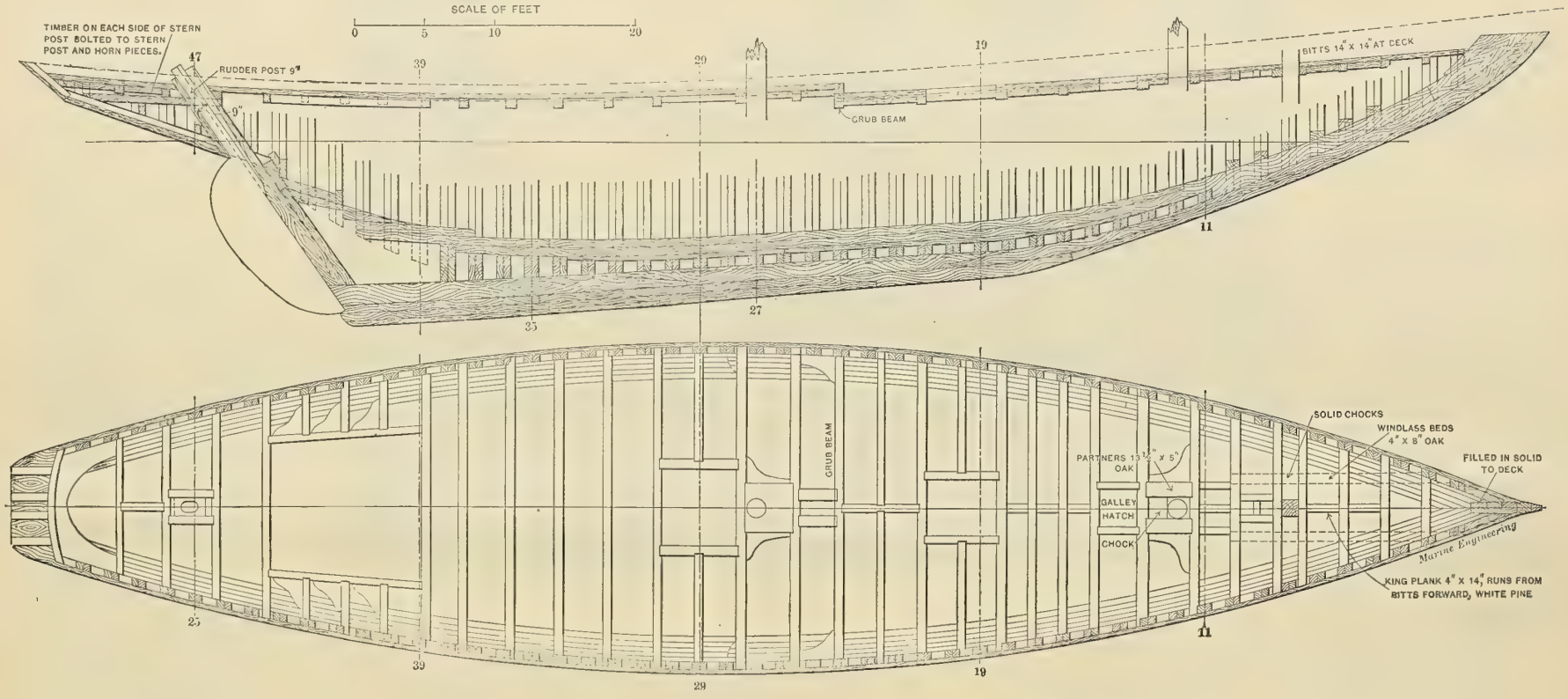
The designer, B. B. Crowninshield, is now engaged in working out the plans for the Lawson *America's* cup defender now building in Boston.

The general dimensions of the *Rob Roy* are: Length over all, 110 ft. 6 in.; on water line, 86 ft.; beam extreme, 23 ft. 7 in.; draft, extreme, 13 ft. 4 in. She is constructed of white oak, and fastened with galvanized iron. The planks and ceiling are fastened with oak treenails and one galvanized spike in each end of the planks, the treenails being wedged on each end after being driven. The two masts and bowsprit are of Oregon pine, as is also the main boom. The other spars are of white pine. The rigging is generally of wire set up with lanyards. Cotton duck is used for the sails, which are bound on the leach and luff with Manila rope, and on the foot and head with Russian hemp bolt rope. Halyards are three strand Manila

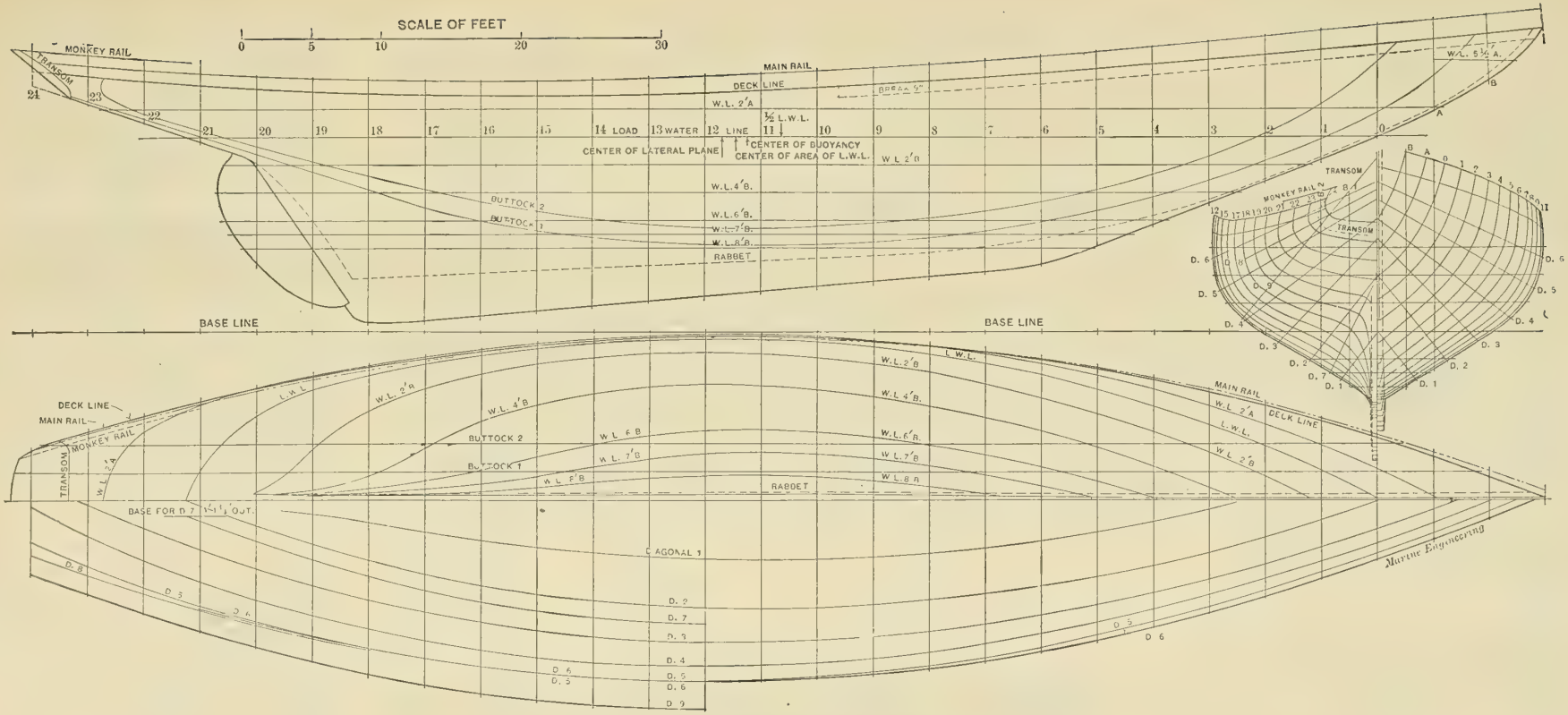
rope. The *Rob Roy* carries 270 fathoms of 8 1-4 in. tarred Manila cable and 45 ft. of 1 in. chain. She has two anchors, one, with wooden stock, weighing 620 lb., and one, all iron, of 650 lb. weight. Complete data of the construction is as follows:

Length over all	110 ft. 6 in.
Length waterline	86 ft. 0 in.
Overhang forward	11 ft. 5 in.
Overhang aft	10 ft. 4 in.
Freeboard stem	7 ft. 0 1-2 in.
Freeboard taffrail	4 ft. 9 in.
Freeboard least, to lowest scupper	2 ft. 9 in.
Draft extreme	13 ft. 4 in.
Draft to rabbet	10 ft. 2 in.
Area L.W.L. plane	1,416 sq. ft.
Area amidship section	125.7 sq. ft.
Maximum immersed girth of hull	36.7 sq. ft.
Displacement	173.4 tons.
Inside ballast	83 tons.
Beam, L.W.L.	23 ft. 1 in.
Beam, extreme	23 ft. 7 in.
Tons per in. at L.W.L.	3.37
Area lateral plane of hull	729.8 sq. ft.
Area rudder	43.0 sq. ft.
Total lateral plane	772.8 sq. ft.
Total wetted surface	2,316.0 sq. ft.
Area sails, 4 lower	5,221.0 sq. ft.
Ratio displacement to L.W.L.	2.04
Ratio sail area to wetted surface	2.34
Ratio length to beam at L.W.L.	3.68
Ratio overhangs to L.W.L.	.256
Ratio rudder to balance lateral plane	.057
Ratio (stem to C.B.) to L.W.L.	.529
Ratio (stem to C.L.R. hull) to L.W.L.	.549
Ratio (C.E. to C.L.R. hull) to L.W.L.	.0329

When the accompanying photograph of the *Rob Roy* was taken, she was engaged in mackereling, and in this she would be out of port anywhere from three days to three weeks, depending upon the location of



LONGITUDINAL ELEVATION AND CONSTRUCTION PLAN OF CROWNINSHIELD FISHING SCHOONER.



LINES OF CROWNINSHIELD FISHING SCHOONER.

the fish. They might be caught off Gloucester or the boat might have to go to the Maine coast for a catch. When mackereling she carries 40 tons of pig iron, 35 tons of rock ballast, and a quantity of cement in her hold. On top of this she can carry about 500 barrels of mackerel.

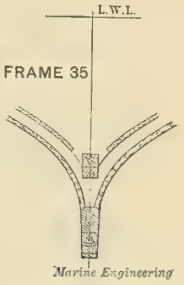
Now the *Rob Roy* is engaged in fresh fishing for the Boston market, being gone about ten days on a trip. When fresh fishing, her catch includes cod, haddock, hake, pollock and halibut, but chiefly cod and haddock. The capacity on these trips is about 200,000 lb. of fresh fish. The fish are iced in the hold, which is fitted with about thirty-two separate "pens," each about 52 in. square, varying in depth, according to location in the vessel. If the market demands she can be sent to Newfoundland for frozen herring, and in that case she would sail with swept hold, carrying only large rocks for ballast, which could be readily dumped on her arrival.

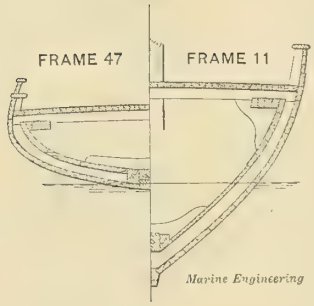
The *Rob Roy* carries a crew of eighteen men. In her cabin aft there is accommodation for the captain, and bunks which usually accommodate four men. Forward, in the forecastle, just aft of the foremast, there are two tiers of bunks, which run away forward—seven on each side. Aft of the foremast is the galley, with large stove, storeroom and pantry.

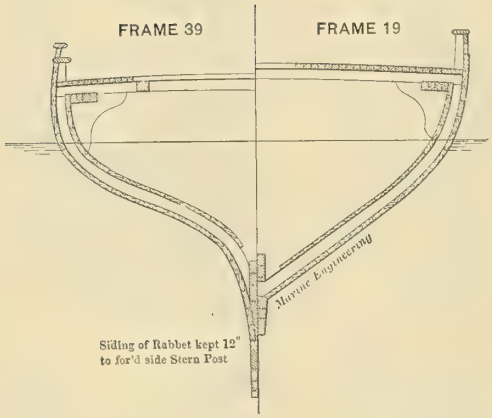
In the mackerel season two seine boats are carried, each 38 ft. long, 9 ft. wide, 3 1-2 ft. deep, and draft about 2 ft. When fresh fishing the *Rob Roy* carries eight double dories, each 15 ft. long. In these the fishermen go out and set the trawls, and also bring in the fish. As the men work on shares, the more fish they catch the more profitable is their work. In addition to his regular share, the captain gets a percentage on the net stock for sailing the vessel.

In winter haddocking very severe weather is often

encountered, but the *Rob Roy* has proved herself a very "able" vessel. In a good breeze she has logged a speed of 12 1-2 knots, but on an average her speed is about 10 miles an hour.







AMERICAN CANAL PROBLEMS WITH SPECIAL REFERENCE TO THE STATE OF NEW YORK.

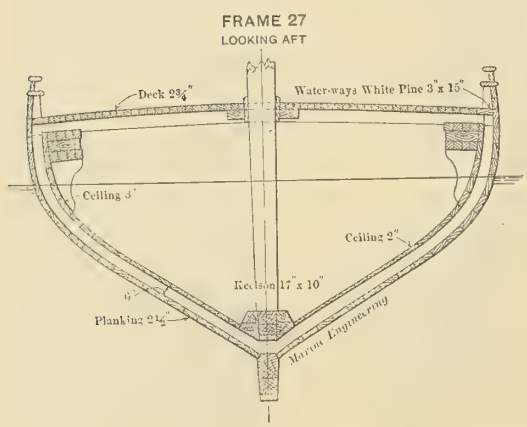
BY ROBERT E. HORTON, U.S.G.S.

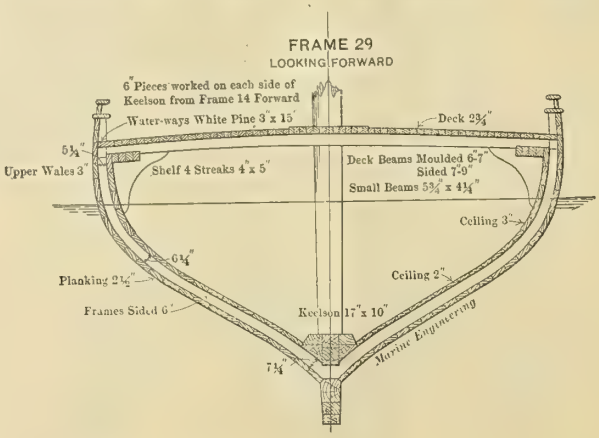
Whatever may be the physical significance of the fact, it is worthy of remark that the nations which have attracted most attention in the panorama of history have been those that dwelt in close communion with the sea. To this Greece, Italy, The Netherlands, England and Japan bear witness.

The United States is approximately a great quadrangle, only the ends of which are washed by ocean waves. The massive configuration of the country has affected material development in many ways. The centers of production of different raw materials which in utilization must be brought together, are often widely separated. In the matter of transportation of large volumes of bulky merchandise, the western producer feels himself almost hopelessly land locked. Nature has provided two means which may be utilized to shorten the line of overland transport from the coal, iron, grain and live stock regions to the coast. The first is the Great Lake system, the second is the Mississippi River. The position of these two great natural inland waterways is shown on the accompanying map.

In order to extend the natural waterway affected by the Great Lakes, a means has long been sought for connecting them with the sea. The dividing ridge or watershed line separating the drainage basin of the Great Lakes from the surrounding region is nowhere abrupt or saliently demarcated. Its approximate position is shown by the dotted line on the map. At a number of points the divide is so low that the proposition has been made to cut through it and connect the Great Lakes with some natural valley draining to the sea. At the Chicago divide the natural rock surface is but a few feet above the mean level of Lake Michigan. At Rome the head waters of Wood Creek and Mohawk River connect so closely that the Indians used the Mohawk Valley for almost continuous canoe navigation from Hudson River to Lake Ontario.

Going back in the geological history of the Great Lakes, we find that the drainage from this inland basin has in time past found its outlet to the sea successively through Chicago-Illinois-Mississippi River valleys, Mohawk-Hudson River valleys, Georgian Bay-Ottawa-St. Lawrence River valleys, and, lastly, through Niagara

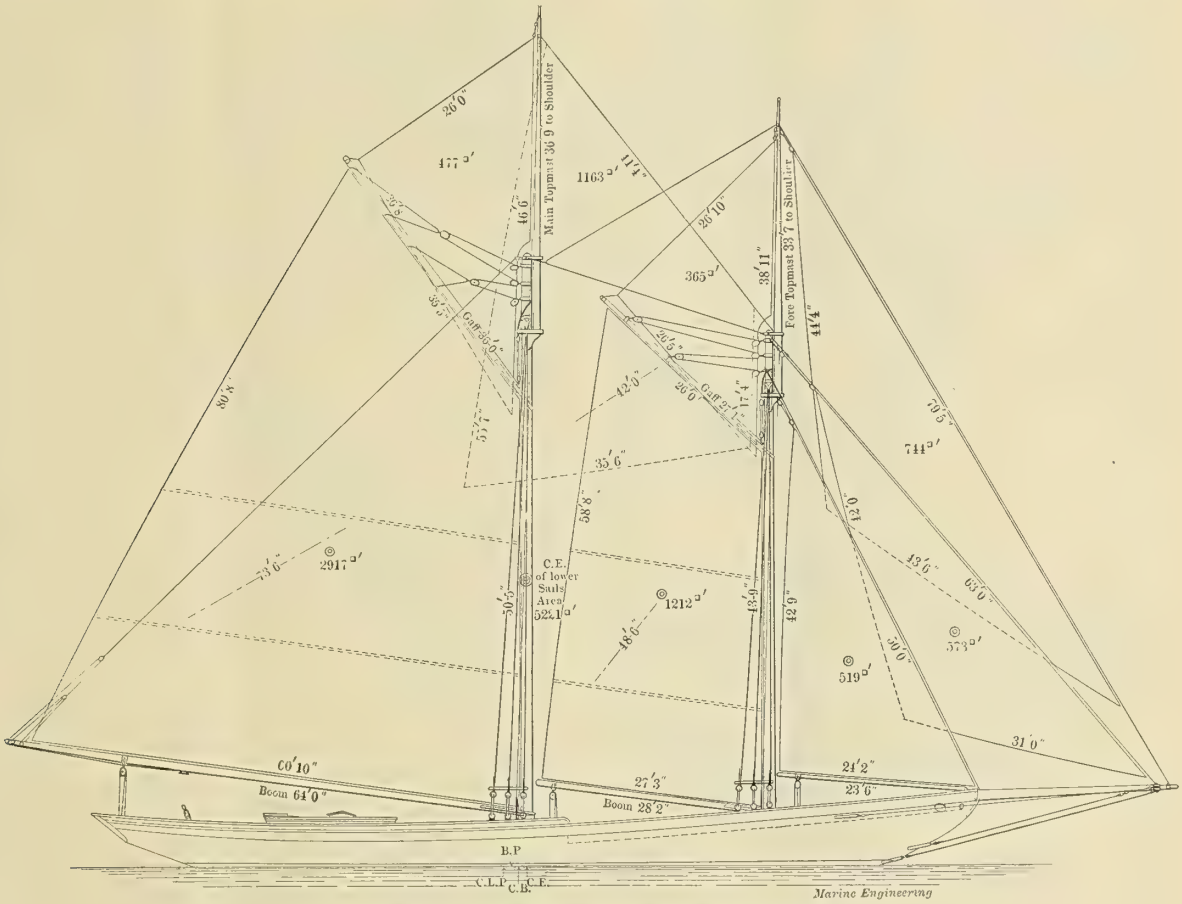




CROSS SECTIONS OF CROWNINSHIELD FISHING SCHOONER.

River, Lake Ontario and St. Lawrence River.[1] The abandoned outlets, owing to the low level at which they cut the divide, offer favorable opportunities for the construction of artificial navigable channels to the sea. Each of those mentioned has been utilized to some extent for this purpose. The Rideau, Ottawa, St. Lawrence, Erie, Illinois and Michigan and Chicago drainage canals all occupy former Great Lake outlets through the whole or a part of their courses.

Briefly stated, the two main canal problems before the people of America are, first, to connect the Atlantic and Pacific oceans by an isthmian waterway; second, to so enlarge and deepen some one of the Great Lake outlets as to enable the largest class of lake craft to pass freely to and from the ocean. As outlined in the foregoing, there are a number of possible solutions to the second problem.



SAIL PLAN OF CROWNINSHIELD FISHING SCHOONER.

To the people of the Empire State the adoption of the Mohawk-Hudson River route appears especially desirable, and it cannot be doubted that a canal that would cheapen transportation rates and continue the current of commerce from the Great Lakes to the ocean by way of Buffalo and New York would be highly conservative of the commercial interests of that State. It is the purpose of this paper to show that the construction of the Great Lakes and oceanic waterway should be based on broader considerations than the mere emolument of one State to the possible detriment of others. On the other hand, New York naturally feels some concern about the matter, owing to the fact that at least one possible solution of the problem might be such as to practically shunt New York State out of the circuit of ocean-bound commerce and deprive it of the prestige it has obtained largely through the construction of the Erie Canal.

Prior to the war with Spain the Central and Western States were almost unanimous in favoring the construction by the Federal Government of a deep waterway channel from the Great Lakes to the seaboard by way of New York or the St. Lawrence River. The United States Board of Engineers on Deep Waterways was appointed to investigate the cost and feasibility of such a channel, capable of floating the largest ocean vessels. One of the two main routes considered contemplated the canalization of the St. Lawrence River; the other, known as the Oswego-Oneida-Mohawk route, was for a canal which should pass through the State of New York, touching its principal cities. In brief, it was found as a result of this investigation that to construct a 30 ft. channel by either of these routes would cost $300,000,000.

Whether or not any national canal will ever be built depends ultimately upon the action of Congress. There

[1] See "Lakes of North America," Israel C. Russell, pp. 96-103. Also "The History of Niagara River," *An. Report Smithsonian Institution*, 1890, pp. 231-257.

appears to be little doubt that if introduced timely a bill for the construction of a ship canal along one of these two routes would have received exceedingly strong support. Of the relative advantages of the two, it may be said that the St. Lawrence would probably interfere with vested rights in less degree and permit of a greater speed of transport. The Mohawk route would place the canal entirely within the borders of this country. If this were done it would enable American war vessels to pass freely to and from the Great Lakes, and in case of emergency warships could be used to protect the coast towns of the lakes or transferred to the open sea as might be required.

If a 30 ft. ship canal were constructed along the Oswego-Oneida-Mohawk route the result would be the expenditure of $300,000,000 largely within the State of New York. Of this the Empire State would have to bear only its fair proportion as an element of the Union. The current of commerce from fertile western regions to the seaboard, via New York, would be forever established. The Empire State would receive an extra advantage from a canal lying within its own borders through its use for internal traffic.

The annual expense of the maintenance of the canal would also largely be disbursed within the State. On the other hand, the management of the canal would fall to the officers of the Federal Government rather than to those of the State of New York; there would be no transferring of goods through-bound for foreign ports, and the cities of Buffalo and New York would be deprived of the profits of the stevedore business. Such in the main would be the results of the construction of a 30 ft. ship canal from the Great Lakes to the Atlantic Ocean.

The United States Deep Waterway Commission did not, however, in its final report recommend the construction of a 30 ft. waterway; but rather that of a 21 ft. waterway following substantially the same route. Aside from the excessive cost and technical difficulties involved in the larger project, it is claimed that the smaller rather than the larger canal would be suited to the demands of traffic. This may be explained as follows: The internal trade of the United States is more than ten times its foreign trade, a large proportion of the internal traffic is carried at some time in its course on the Great Lakes. The traffic through the Sault Ste. Marie ship canal amounts to about 25,000,000 tons per year; that through Detroit River to 40,000,000 tons per year, or nearly five times as much as the annual traffic of all nations through the Suez Canal. In view of the evident disproportion between the amount of internal and foreign transport, it appears that the dimensions of the waterway connecting the Great Lakes with the sea should be controlled by the demands of the former rather than the latter class of traffic.[2]

Compared with the first mentioned project, a 21 ft. ship canal through the Oneida-Oswego-Mohawk route would, it is estimated, cost but $200,000,000, or two-thirds the cost of the 30 ft. channel. It would accommodate a large class of seagoing merchant vessels and at the same time it would be adapted to the class of lake vessels which have been shown to be most economical for lake traffic. It would admit of through shipment of western produce on such vessels without transfer from Chicago to New York in a period of six days. Its advantages to the nation at large would therefore nearly equal those of the 30 ft. waterway, with the exception that the largest merchant or war vessels could not pass through it. As related to the interests of the State of New York, the effect of its construction would be about the same as for the larger waterway. The largest merchant vessels now building are about 700 ft. long and 75 ft. beam. Such ships could not, of course, enter the smaller canal, and there would be a certain amount of transfer business at New York on export shipments.

Turning now to the question of the construction of the canal by the State of New York instead of by the Federal Government. The preferred proposition seems to be the supplanting of the Erie Canal by an enlarged barge canal designed for vessels of 10 ft. draft and 1,000 tons burden. The cost of such a waterway would be about one-third that of the 21 ft. ship canal just considered.[3] It would, however, be a barge canal. It would not accommodate the largest and most economical class of lake freight carriers, nor would it admit naval war vessels or marine merchantmen of the larger types. The transfer of cargoes with consequent delays would be necessary at Buffalo and New York for through shipment of the products of the West. The cost to the people of the State of New York would be greater than their share in paying for a national ship canal. On the other hand, such a barge canal, if built, would lie entirely within the Empire State and would be owned and manned by the State and controlled by State officials. It would undoubtedly exert some influence to reduce freight transport charges by rail; less influence, however, than a ship canal, by an amount somewhat proportional to the difference in cost due to transfer charges at the ends.

In order that such a canal should accomplish its acknowledged purpose of maintaining the commercial prestige of New York State it would have to depend largely on through traffic from the western producer. The people of the West desire an enlarged waterway from the Great Lakes to the seaboard, chiefly for the purpose of obviating the necessity of transferring cargoes en route. The Dominion of Canada has recently completed a system of waterways along the St. Lawrence route, capable of receiving vessels of 14 ft. draft. The Canadian canal system utilizes the St. Lawrence River throughout the major portion of its length, seven short lateral canals having been built around rapids or shoals in the Niagara and St. Lawrence rivers. A large portion of the traffic received since its completion has consisted of foreign bound shipments from ports of the United States.[4] The Canadian canal system does not fully obviate the necessity of transfer of cargoes. It would, however, be a strong competitor for western traffic with the New York barge canal, if the latter should be built.

During the delay incident to the investigation made

[2]See "Canals Between the Great Lakes and New York N. Y." Joseph Mayer, M. Am. Soc. C. E. Also "The Economic Dimensions of a Waterway from the Great Lakes to the Atlantic," by George Y. Wisner, M. Am. Soc. C. E., *Proc. Am. Soc. C. E.*, October, 1900, pp. 902-1004.

[3]See Report of Edward A. Bond, State Engineer and Surveyor on New York Barge Canal Survey, Albany, 1901.

[4]See Statistical Year Book of Canada, 1899.

by the United States Waterways Commission, the Spanish war brought prominently to public notice the imminent need of an isthmian canal connecting the Atlantic and Pacific oceans. The exigencies of coast defense in time of war demand a means of rapidly transferring naval fleets or vessels between the eastern and western coasts of the country. New Oriental possessions invite commerce. The western producer finds himself land locked between two oceans. Under the present system the products of the great mining and agricultural region lying between the Rocky Mountains and the Great Lakes, destined for the Philippines or Atlantic seaboard would, it is evident, make the prospect more inviting to the western producer who wants a share in foreign trade. With reference to such a ship canal the question arises whether the Federal Government would or should become involved in two enormous canal projects at the same time, as would be the case were the isthmian and Great Lakes waterways both to be undertaken at once. Furthermore the State of New York apparently favors an enlarged barge canal which will not obviate transfer charges. In view of this situation, the people of the West have begun to look about for another outlet to the sea and have apparently lost

MAP OF NATIONAL WATERWAYS OF THE UNITED STATES.

the ports of the Orient, have to be carried overland to Duluth or Chicago, transferred to lake vessels for shipment to the terminal of the Canadian or New York Barge Canal, again transferred for passage to the sea coast and there loaded on marine vessels bound for the Pacific ports via Cape Horn. The people at large would undoubtedly favor the construction of an isthmian canal at once, provided its continuous utility to the commercial interests of this country at all times, whether in peace or war, could be assured:[5]

A ship canal connecting the Great Lakes with the interest in the project for a ship canal through the State of New York. The outcome of their search has been the development of an entirely new project, namely, the construction of a waterway from the Great Lakes to the Gulf of Mexico by way of the Chicago Drainage Canal, Illinois and Mississippi rivers.[6] The cost of constructing a 20 ft. canal through this route has been estimated at less than $200,000,000, or about the same as the cost of a Federal canal 21 ft. deep from the Great Lakes to the port of New York. So far as traffic from

[5]See Preliminary Report of the Isthmian Canal Commission, Washington, 1900.

[6]See "A Deep Waterway from the Great Lakes to the Gulf of Mexico." Papers before Western Society of Civil Engineers by James A. Seddon, Lyman E. Cooley and Isham Randolph.

the Great Lakes is concerned, the Mississippi Canal would afford facilities entirely comparable with those of the proposed 21 ft. waterway along the Mohawk route, recommended by the United States Deep Waterways Commission, and far greater than those of the 12 ft. barge canal proposed by the New York State Commission. If an oceanic waterway should be constructed across the Central American Isthmus, the advantage of a waterway from Chicago to the Gulf of Mexico for shipments to the Pacific is very evident. The Mississippi River reaches out its arms from Manitoba to southwestern New York and divides the nation into an eastern and western part. Ohio, Missouri and Illinois rivers and other branches are now maintained in a navigable condition by the Government at large, and with the fullest possible utilization of the branches as feeders, and an opportunity for the direct shipment, without transfer, of foreign-bound goods from the ports of the Great Lakes down this channel to the Gulf of Mexico, thence seaward to their destination, the effect would undoubtedly be to change the direction of the current of commerce from eastward to southward, and ultimately the industries and interests of the eastern and western halves of the country would become strongly contrasted.

The proposed Mississippi waterway possesses interesting features. At the northern end the drainage channel, constructed by the city of Chicago for sanitary purposes at a cost of $35,000,000, would be utilized. This channel has been excavated to a depth of 24 ft. below mean low water of Lake Michigan. It cuts across the divide between the drainage basins of the Great Lakes and Mississippi River, and when completed the diversion of 10,000 cu. ft. of the water per second from Lake Michigan to the Mississippi River is contemplated.[7] Careful records of lake levels kept during the latter half of the past century, indicate that elevations and depressions of the margins of the Great Lakes are continually going on, the general effect being a gradual tilting of the entire Great Lake basin in a southwesterly direction, with such a rate of progress that in the course of a few centuries the waters of most of the lakes of the system would again spill over the Chicago divide and empty into the Father of Waters through their long abandoned channel.[8]

As an extreme case, it may be worth while to picture the resultant effect on the commercial interests of the Empire State of the construction of the Great Lakes and Mississippi Ship Canal in conjunction with a national canal connecting the Atlantic and Pacific oceans. It appears very doubtful whether any canal which can be constructed through the State of New York, whether calculated for barges or full-sized lake carriers, could successfully compete with the Mississippi waterway for foreign-bound commerce.

The proposed Mississippi waterway involves two great difficulties, with both of which the Government has, however, contended for a long time past. These are the control of the floods of the lower Mississippi and the maintenance of a clear channel for navigation through the continually changing deposits of sediment of the Mississippi delta.

There is a large volume of internal commerce between the West and the East that would be benefited by a canal through New York State. A ship canal to the sea, by either the St. Lawrence-Champlain route or the Illinois-Mississippi route, would utterly fail to answer this requirement. In this fact lies the justification of the State of New York in her effort to construct a canal of her own regardless of what the Federal Government may do. As pointed out above, the advantage that would accrue to the people of the West from the construction of an Illinois-Mississippi canal would depend to some extent on whether or not an interoceanic canal were constructed. If in the chance and change of future Congresses a Federal waterway along the Mohawk route should gain prestige over other projects, the advent of the larger channel would make the barge canal obsolete and unnecessary.

In view of the general trend in favor of an isthmian canal as the first great Federal waterway, the attention of the West now turns to the Mississippi rather than the Mohawk route, and the indifference or opposition of New York to the construction of a ship canal which would obviate transfer of cargoes at her ports; the present chances for the construction of a Federal deep waterway from the Great Lakes to the port of New York, seem rather remote.

Elaborate surveys have been completed and estimates made for the Mohawk route ship canal. All the details have been settled upon. There are no international problems to cause interminable delay. If the Empire State would abandon its project for a barge canal and heartily co-operate in the promotion of the larger project, it would, perhaps, gain precedence over even the long delayed Isthmian Canal.

Whether or not a ship canal is ever built, the Federal Government, through its assumed authority over public waterways, is bound to exert its influence for the maintenance of sufficient channel depths through the connecting waters of the Great Lakes; for the regulation and amelioration of floods of Mississippi River, and for the maintenance of a navigable channel through the Mississippi delta. Large sums of money are annually expended for these purposes without the accomplishment of permanent results.

If a ship canal is built by either route it will be necessary to maintain at all times a navigable depth throughout the Great Lakes and their connecting channels at least equal to that of the canal itself. The lake levels are subject to a natural fluctuation of several feet.[9] A means of controlling the level of the lakes and maintaining the water surface continuously at a relatively unvarying stage near the high water mark would be of the utmost value.

The estimate of $200,000,000 of the U. S. Board of Engineers on Deep Waterways for a 21 ft. through channel to the seaboard, includes a plan for accomplishing this result.[10]

[7]See Report of Special Commission Chicago Drainage Canal to the Governor of Illinois, 1900.

[8]See Recent Earth Movements in the Great Lakes Region, G. K. Gilbert, 18th Annual Report U. S. Geological Survey, Part II, pp. 601-653.

[9]See (1) Report U. S. Deep Waterways Commission, 1896; (2) Proceedings First Annual Convention International Deep Waterways Association, Cleveland, 1896; (3) "Reservoir System of the Great Lakes of the St. Lawrence System," by Hiram M. Chittendon, *Trans. Am. Soc. Civil Engineers, Vol. XL, 1898.*

[10]See Preliminary Report U. S. Board of Engineers on Deep Waterways on The Regulation of the Great Lakes, 1900.

Similarly the estimate of $200,000,000 for the Illinois-Mississippi Canal includes the construction of a vast storage reservoir in the flood plain, by which the discharge of the Lower Mississippi could be controlled. Previous to the construction of levees, the natural flood plain of the Mississippi, covering 30,000 square miles, acted as a storage reservoir during the passage of flood waves; the effect of the construction of levees has been to restrict the water to a narrow channel, thereby increasing the flood stage and the consequent height of levees required.[11] Thus the levee system defeats its own purpose to some extent. The utilization of a part of the natural flood plain as a storage reservoir would result in the abandonment of the expensive levee system and permit of the final reclamation of a vast area of fertile alluvial bottom land.

The effect of the use of jetties to maintain a navigable channel through the Mississippi River has not been all that could be desired. The jetty, by restricting the channel in one section, raises the flood level and also causes a checking of the velocity above, producing deposits of sediment equally deleterious with those it avoids. The problems of the Mississippi River are of the most stupendous nature. It has a maximum flood discharge of nearly 2,000,000 cu. ft. of water per second, and annually brings down to be deposited wherever the velocity of the current is checked, a load of 7,500,000,000 cu. ft. of sediment.[12] The proposition to control the floods and at the same time increase the minimum channel depth by conserving the flow through storage of the flood waters in a vast reservoir of 7,000 square miles area in the St. Francis River basin, looks very attractive.

In view of the great individual importance of the problems of lake level and river flood control, and their intimate relation to the leading deep waterway projects, it appears that from these considerations alone, the selection of a route for a national waterway from the Great Lakes seaward should be based on no other consideration than the prospective interest of the nation at large, considered in the broadest sense.

TRANSATLANTIC RECORD.—In a race across the Atlantic from Liverpool to Philadephia, the four masted American ship *Kenilworth* eclipsed all recent sailing records when she arrived at Philadelphia from Liverpool in 18 1-2 days.

S.S. SATSUMA.—The new steamship *Satsuma* was launched from the yard of Short Bros., Sunderland, England. She is for the New York & Oriental Steamship Co., which runs a regular line between New York, Manila, China and Japan. This vessel, which will be fitted with the latest improvements and will have extra facilities for the rapid handling of cargo, is of these dimensions: Length, 382 ft.; beam, 48.7 ft.; depth, 30 ft., with a capacity of 7,200 tons dead weight.

[11]See (1) The Floods of Mississippi River, by William Starling; (2) Floods of Mississippi River, by Park Morrill, U. S. Weather Bureau, 1897; (3) Report on Mississippi River Floods, U. S. Senate Committee on Commerce, 1898; (4) Reservoirs and their Effect on the Floods of Mississippi River, by James A. Seddon, U. S. Assistant Engineer.

[12]See (1) "Hydrography of the Mississippi," by James T. Greenleaf, C. E., *American Journal of Science*, July, 1896; (2) "Improvement of South Pass of Mississippi River," by William Starling, *Engineering News*, Aug. 23, 1900.

SUBMARINE BOATS—FROM THE EARLIEST RECORDS DOWN TO THE PRESENT.*—VIII.

BY CARL BUSLEY.

CHAPTER XXXIV.

General Conclusion.—On close examination of the results, reports of trials and experiences with submarine boats the following bad qualities are most apparent: (1.) Poor stability. (2.) Danger in handling. (3.) Small visual range. (4.) Low speed. (5.) Small radius of action. (6.) Expensive construction.

(1.) The poor stability of the completely submerged boat lies in the fact that the specific gravity of the boat is equal to that of the displaced water, and also in the absence of buoyancy. One point that is generally overlooked is that the center of displacement of a submerged boat never changes its position, no matter how the boat may list or incline, in comparison to the ever changing position of this point in a vessel when rolling or pitching on the surface, in the usual way, caused by certain parts being alternately submerged and emerged. Another point which is not generally recognized is that the stability of a submerged boat improves the further its center of gravity is below the center of gravity of the displaced water, and that this latter fact is of just as great importance to a submarine boat as the metacenter is to a vessel sailing on the surface. A sufficient 'thwartship stability can therefore always be attained in a submarine boat by making its midship section of a shape similar to that of an egg standing on its pointed end. If, with such a section, the bottom is filled with ballast, the center of gravity will be low and the center of displacement will be somewhat high. The question of fore and aft stability, that is, remaining on an even keel, is very difficult to solve. The slightest shifting of weight forward or aft, such as caused by the movements of the crew, which naturally are unavoidable, will immediately cause the boat to incline, and this can only be corrected by the instant shifting of ballast. This poor fore and aft stability was the main fault of Bourgois' *Plongeur*, and has remained a fault in all submarine boats of any appreciable length. Bauer tried to correct it by his fore and aft movable weight. Drzewiecki and Holland tried their automatic pumping arrangement for shifting water ballast. Goubet tried to overcome it in a more sensible way, as he made his boat as short as possible, so that the crew of two men did not need to leave their seats in the middle of the boat. Nordenfelt and others gave their boats a slight buoyancy when submerged, forced them down with the forward and after vertical propellers and attempted to hold them on an even keel by varying the speed of these propellers. Naturally far better results are obtained when the slight buoyancy is not counteracted; that is, having the boat only partially submerged. This, as well as the better visual range, seems to be the main reason of the adoption of the partially submerged type. Even in that type, however, it is evident that the length is an important factor, as may be judged by the gradual reductions made by the French from the *Gustave Zédé*, 147 1-2 ft., to the *Morse*, 118 ft., and the *Naval*, 111 1-2 ft.

(2.) The danger in handling submarine boats increases in inverse proportion to the depths to which they

are designed to sail at. Most of the boats have been built so strong that they could stand submersion to a depth of 100 ft., but even so, inside of one-half minute they could get to a depth where the pressure would be above their limit of resistance to collapse. Let us assume that a boat has a speed of 8 knots, or about 13 ft. a second, and two of the crew go forward to put a Whitehead torpedo in the bow tube. The boat will immediately incline forward, a quantity of bilge water will also flow forward, and even if the angle of incline is only 15 deg., inside of 30 seconds she will be in a critical depth. If, inside of this short time, there should be any derangement of the engine, ballast, or the horizontal rudder, which could not correct this incline immediately, at this speed and angle the pressure on the hull would increase at the rate of 1 1-2 lb. per sq. in. per sec., and it is questionable if, under such conditions, the release of a safety weight at the bottom could be effected quickly enough to prevent a catastrophe and allow the boat to come to the surface and be picked up by the enemy. A second great danger to submarine boats is the unevenness of the bottom of the sea along the coasts. According to the French reports of the performance of the *Gymnote*, their course under water is not a straight line, but a more or less wavy line, and it is therefore very likely that they might run into a sand bar or mud flat in such a position that they could not free themselves with their own power. The well-known English admiral, Lord Charles Beresford, made a trial trip in Campbell's boat at Tilbury in 1886, in which the boat ran fast into the mud at the bottom of the Thames, and they succeeded in freeing her only with the greatest difficulty. The writer has had the opportunity to see a tank trial made with the model of a submarine boat at the "Kette" shipyard in Uebigau. The model had a midship section for good 'thwartship stability, and the curves of resistance were good as long as the model was partially submerged. As soon as it was fully submerged and had no buoyancy whatever, the wavy course was so marked that no towing trial could be finished.

(3.) The small visual range under water may be explained by a formula in which the intensity of the light i emanating from a body with the strength, after penetrating a strata of water of x meters in thickness reduces to $i = e - \frac{x}{e}$, in which "e" is the basis of the natural logarithms = 2.7183 and c = 3.0232, a constant derived by experiments. According to this the light from a submerged body is reduced to the one ten-millionth part of its original intensity at a distance of only 100 meters. The human eye is not sensitive enough for such enormous reduction, and this can also be demonstrated by the fact that an object placed under a microscope of magnifying power of one and one-half million can not be seen at all when illuminated by bright daylight. Furthermore the illumination of an object under water by bright daylight can not be depended upon, as part of the rays cannot penetrate the water owing to reflection from the surface, and in addition there would be further losses, as, for instance, those caused by the glass of the windows in the conning tower. It can, therefore, be readily understood why a diver at the depth of 20 ft. can see for a distance of only 25 ft., and this only in the brightest daylight and perfectly clear water. Search lights would be of no use whatever, and would probably only betray the presence of the boat to those above water. Bauer declared emphatically that he could locate the hull of a ship at a distance of 300 paces in the clear waters of the Baltic, but since then this has been proven to be false. Furthermore, the utility of the vertical tube and mirror, as adopted by the French, cannot amount to much, as its close proximity to the surface makes the visual range so small as to prevent proper aim when ejecting a torpedo.

(4.) The low speed of only 8 knots, which is not even exceeded by the latest partially submerged boats at deep draft, makes a very poor showing when compared to the 18 knot speed of the latest battleships or the 30 knot speed of the destroyers. The principal cause of the low speed is due to the great weight of the storage batteries, which, for a night attack in a sheltered harbor, must have capacity for at least five to six hours of maximum power, and consequently will weigh about 150 lb. to a horse power developed. The machinery of the latest torpedo boats does not weigh even one-tenth of this for the same performance. As the recent development of the storage battery system does not give much promise of a radical reduction in weight, an appreciable increase in speed of submarine boats cannot be looked for in the near future.

(5.) The small radius of action of only 20 miles possessed by the submerged *Goubet II* at the maximum speed of 5 to 6 knots is increased to 45 miles in the case of the *Gymnote*, with 10 knots speed at light draft, and decreases again to only 25 miles in the case of the *Narval*, sailing at 8 knot speed when almost submerged. This radius of action is only about the one-hundredth part of that of the new battleships and torpedo boat destroyers at similar speed, showing that the use of the submarine boat is very much limited, and that its service would be entirely confined to the near neighborhood of the home port.

(6.) The expense of construction can be judged when it is stated that the *Morse* cost $130,000 exclusive of armament, which, if included, would have brought the price up to $150,000. In comparison, a torpedo boat destroyer of three times her displacement and four times her speed, would only cost about $50,000 more.

The technical difficulties in connection with submarine boats, especially their unmanageability in regard to fore and aft stability, which has existed from the first attempt right up to the present time, do not permit of much promise for the future. The partially submerged boats are in about the same position, as good authorities all state that they are very poor sea boats, and get into very dangerous positions when overtaken by bad weather. Even the inventors of such boats, like Hovgaard and Holland, for this same reason propose to build such boats that they can sail on a light draft in order to have a certain amount of freeboard to live through a sudden gale. Under such circumstances their widely advertised invulnerability to the enemy's fire would be *nil*, and therefore it is a question whether it would not be more advisable to give them a permanent freeboard of suitable dimension, and instead of a 13 knot speed to give them a 30 knot speed, which, of course, would develop them into the modern type of torpedo boat.

SIDE WHEEL STEAMER IRELAND, EQUIPPED WITH OSCILLATING ENGINES.

PASSING OF THE OSCILLATING ENGINE—SALE OF THE S.S. IRELAND.

After a comparatively short life in the trade for which she was built, the famous side wheel steamer *Ireland* was recently sold at Liverpool to the owner of a marine graveyard at Brest, France. In the opinion of many competent judges, this Irish mail steamer was the finest specimen of side wheel construction, for channel service, ever turned out of a British yard, and as it is highly improbable that a vessel of similar construction will ever again be built. some record of her dimensions and performances is of widespread interest.

In British practice, for many years, the oscillating engine, for paddle vessels, had as firm a hold as the beam engine in this country. In fact, it is only a few years ago that practically all of the crack vessels in service in the narrow waters surrounding the British Isles were fitted with this type of engine. It never made much headway on this side of the Atlantic for the reason, among others, that our sound and river steamers are of comparatively light draft and usually built of wood, the flexibility of hull being unfavorable to this type of engine. Increasing pressures finally forced the adoption of compound and triple engines, which, owing to difficulties of construction, could not be successfully built on the oscillating plan. In more than one instance indeed the oscillating engines were removed from cross channel vessels, and replaced by triple expansion engines, with, of course, complete new boiler installations. Later the twin screw gave opportunity to use large powers on light draft, and a handiness of manœuvring, in narrow and crowded harbors, that was not possible with the single screw; so the propeller has superseded the paddle to a very considerable extent in British coast practice.

To return to the S.S. *Ireland*. She was built in 1888 at the Laird yard, Birkenhead on the Mersey, for the City of Dublin Steam Packet Co. At the time the *Ireland* was built there were four iron steamers on this route, named after the four provinces of Ireland. They were fitted with oscillating engines of 4,500 horse power and had a maximum speed of 18 knots. The *Ireland* was designed to excel these vessels in every way, especially in the matter of speed. She was built of steel and her dimensions were: Length, 377 ft. 8 in.; beam, 38 ft. 4 in.; draft, 15 ft. 6 in. She was fitted with twin cylinder, simple, jet condensing engines, with cylinders 8 ft. 6 in. dia., and 8 ft. 6 in. stroke, and four double ended boilers, with four furnaces in each end, built for a working pressure of 32 lb. per sq. in. Her speed on the measured mile was 21.4 knots, but it has been authoritatively stated that she was never run "wide open." Possibly under such circumstances the vibrations would have been uncomfortable for passengers. In her service the maximum speed was not demanded, as the *Ireland* ran on the schedule of the older vessels, one of which averaged, for 1,000 consecutive voyages, 3h. 33m. for the run from the pier head at Kingstown to the pier head at Holyhead, a distance of 56.75 nautical miles. This is without any deduction for delay by fog, storms or other causes. In regular service the *Ireland* developed about 6,000 I. H. P.

On August 26, 1885, the *Ireland* made her first across channel passage in 2h. 57m., the return trip to Holyhead being made under easy steam in 3h. 7m. On the following day, the trip to Kingstown was made in 2h. 46m. The vessels of this company carry only mail matter and passengers, not taking on any cargo nor even express packages. The *Ireland* carried her first mails September 9, 1885, and completed her last trip in the service March 28, 1897. About that time the owners replaced their old paddle fleet with new twin screw vessels—maximum speed 24 knots—which we described at the time.

Subsequently the *Ireland* was held as a reserve boat, until the success of the screw vessels was established, and then she was sold out of the line. Last year she was put in service in the exclusively passenger trade —one of immense proportions—between Liverpool and the Isle of Man. Her career with this company brought to light some interesting practices of the British shipping trade, which are not very creditable to a nation boasting of the thorough manner in which its business is conducted. There is keen competition in the Isle of Man trade, and the *Ireland* was run by an "opposition" company, and was always "in trouble." On one of her trips from Liverpool last summer the *Ireland*, instead of making the passage in about 3 1-2 hours, occupied about 18 hours in the effort. In an inquiry, subsequently held, it was disclosed that she had left Liverpool with only seven men in the fire room, with thirty-two fires to manage, and the chief engineer and assistant engineer, who had both joined the ship only about one hour before she started, had to call on the deck department for aid. Two seamen and two stewards were then added to the fire room force, and the *Ireland* managed to get to the Mersey bar in an hour. It took more than four hours to get 18 miles further out. Meanwhile five furnaces in the port forward boiler came down, and on the suggestion of the chief engineer all fires were drawn and the boilers emptied and filled. Several hours passed, of course, before steam was up again, and, finally, when the vessel arrived off Douglas harbor, there was not enough steam to make a landing, and the passengers were put ashore in the boats.

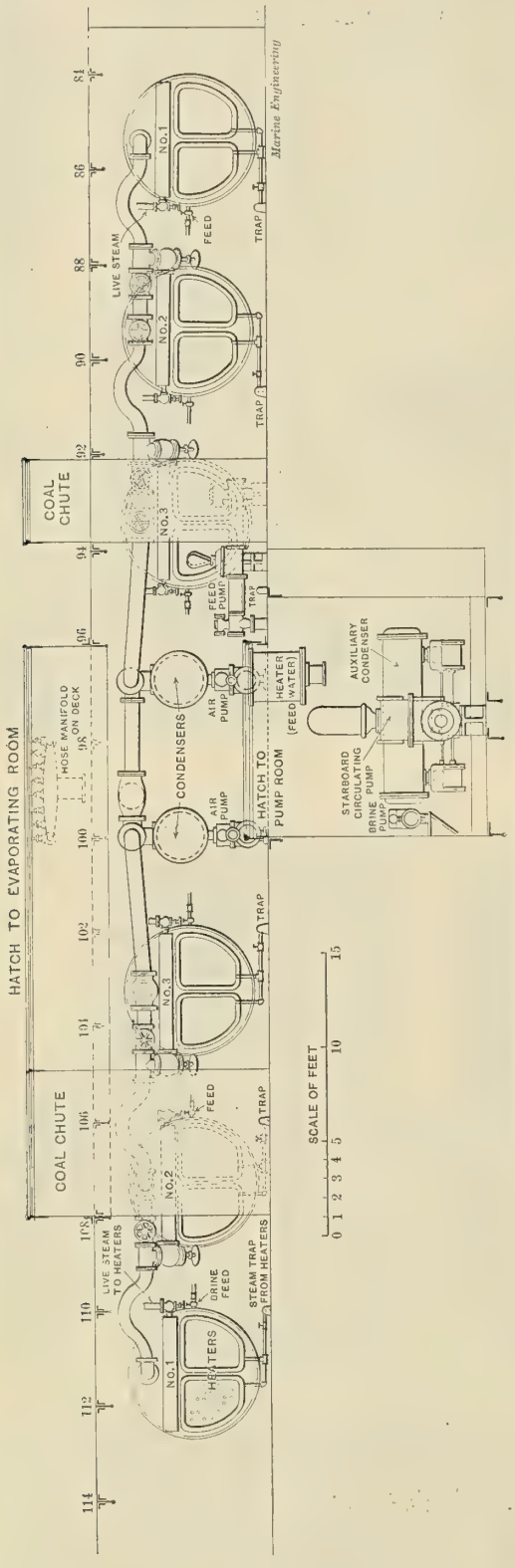
Upon the return of the *Ireland* to Liverpool the Board of Trade inspectors condemned eight of the furnaces, and found that the boilers were badly salted. Blame for the mishap was placed on the engineers of the vessel, and the owners, who probably had a substantial "pull," were not censured.

It is not improbable that the engineers had been accustomed to the use of surface condensers, and were consequently not expert in keeping the water in the boilers at the proper density. They experienced great difficulty in maintaining a vacuum, probably because the exhaust trunnions were not properly packed, a frequent source of trouble with the oscillating engine.

During the period the *Ireland* was run in the service for which she was built, she proved herself a very fast, steady and comfortable boat, making good time even in the most frightful weather. She was then in the hands of capable men with a sufficient crew and proper attention in the way of maintenance.

DECK VIEWS ON BOARD S.S. IRELAND.

FRESH WATER DISTILLING PLANT ON THE U. S. STORE SHIP IRIS.



LONGITUDINAL ELEVATION OF DISTILLING PLANT ON U. S. STORE SHIP IRIS.

Among the additions to our naval vessels which the war with Spain first suggested is the "Distilling Ship," which has become an indispensable adjunct to a squadron operating at a distance from an adequate fresh water supply. It will be recalled that during the war two vessels were purchased on the recommendation of Engineer in Chief George W. Melville, U. S. N., and converted into distilling ships. While they were not ready before the close of active operations of the war, one of these vessels, the *Iris*, was later sent to Montauk Point, L. I., and supplied fresh water to the troops encamped there. This ship has since done good service in our Navy, and is now attached to the Asiatic squadron. The chief purpose of the distilling ship is to supply fresh water to the war vessels for make up feed, as the distilling plants carried on naval vessels have not sufficient capacity, ordinarily, to supply all the fresh water needed for personal uses and feed, except at very low rates of speed. The large supply of coal carried by such ships would also be useful in case of an emergency in which coal was needed more than water.

The *Iris* is an iron steamship built at Newcastle-on-Tyne in 1885, and was originally the British S.S. *Drydem*. Her dimensions are: Length 304 ft.; beam 39 ft.; depth 25 ft.; gross tonnage 2,715 tons; displacement 6,100 tons. She is fitted with a single screw, driven by compound vertical engines, 31 and 70 by 48 in., of 1,320 I. H. P. and at 10 knots speed has a steaming radius of 3,100 miles. She has two, main, double ended, and one, donkey, single ended Scotch boilers, with 154 sq. ft. grate surface and 5,114 sq. ft. total heating surface. Her complement is 10 officers and 64 men.

The distilling plant is located in the forward 'tween decks, over the forward main hold. The accompanying diagram shows the general arrangement. It will be seen that the entire plant is located on this deck, with the exception of the pump room, which is situated under the center of the plant.

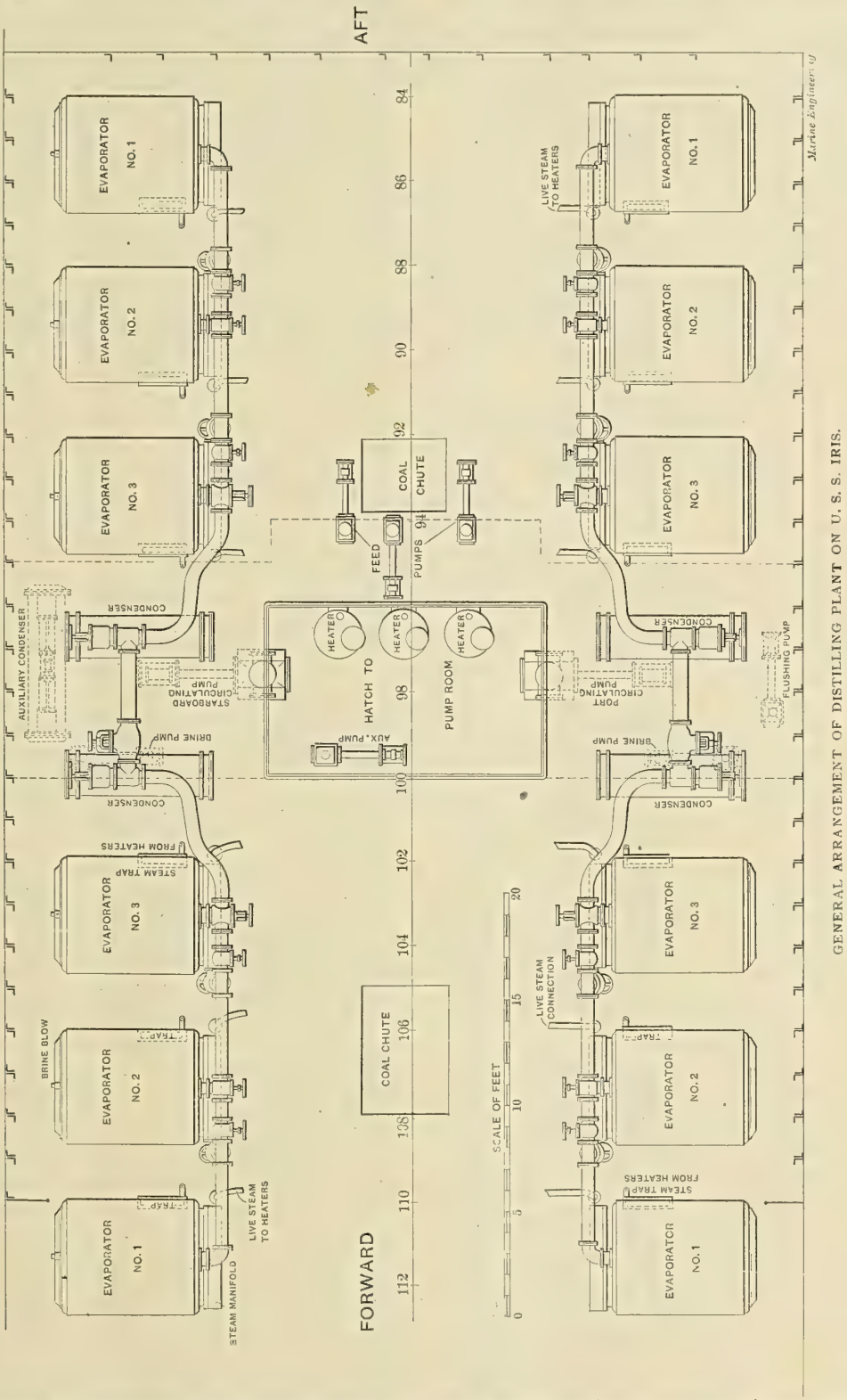
There are twelve evaporators, divided into four groups of three each. Each evaporator shell is 5 ft. 6 in. dia. and 6 ft. 4 in. long. The heater tubes are horizontal, arranged in two nests with cast iron headers. The front headers connect with manifolds for the admission of steam and are so jointed that the heaters may be easily withdrawn for purposes of scaling and inspection. The total heating surface for each evaporator is 320 sq. ft. Traps are fitted to draw off water condensed in the heaters.

Four condensers of 300 sq. ft. cooling surface each, with air pumps attached, are located at the center of the plant; one for each group of evaporators. The circulating water is supplied by two pumps, situated in the pump room below the condensers. There are three feed pumps, situated abaft the pump room on the same deck with the evaporators.

The three feed water heaters are in the upper part of the pump room near the feed pumps. At either end of the pump room is a brine pump for drawing off the dense brine. In the starboard end of the pump

room there is an auxiliary condenser, with direct connected air and circulating pumps. This is used for all pump exhausts and for winches when working cargo. In addition there are two other pumps; one for flushing and another for delivering fresh water overboard when required in small quantities.

The three evaporators in each group are worked in series. Steam from the boilers enters only the heater tubes of the first evaporator. The steam from brine in this shell passes over to the heaters of the second evaporator. The steam generated in this shell again passes on to the heaters of the third evaporator. From the shell of the last evaporator the steam passes direct to the condenser. The water drawn from the heaters of all evaporators also passes through the condenser to become cooled.



GENERAL ARRANGEMENT OF DISTILLING PLANT ON U. S. S. IRIS.

Marine Engineering

By this arrangement the steam pressures are stepped down in four stages from that in the first heater to that of the last shell. The main boiler pressure is 80 lb. and the pressure in the first heater is kept at 60 lb.; this gives about 40 lb. in that shell and therefore about the same in the heaters of the second evaporator. The pressure in the shell of the second evaporator and in the heaters of the third is about 20 lb. In the shell of the third evaporator the pressure is regulated by the valve connecting with the condenser. This is usually kept at 4 lb., any further reduction being apt to cause priming.

The brine level in the shells is kept at about three-eighths of the diameter; it then covers three-quarters of the heater tubes. The density is not allowed to exceed 2.5. The brine pumps are never used, as the pressures are high enough to allow blowing down by simply opening the blowdown cock overboard. The pressures in the "third evaporator" shells may be easily raised if necessary.

In practice only one feed pump is used to supply all evaporators. This is found more convenient than running three pumps at different pressures, each to feed a corresponding evaporator in all four groups. The feed water heater is worked by exhaust steam from all pumps.

The traps for draining the heaters have never given satisfaction, so they are kept open and water drawn off by regulating an ordinary valve. Gauge glasses on the heaters render this an easy matter.

If necessary any evaporator may be cut out entirely, or live steam admitted to any heater. Pipe connections to the condensers admit changes, so that one condenser may take all, or any part, of the output of two groups on the same side of the ship. The distillate from one condenser is always required to supply feed for the main boilers in addition to that returned from the auxiliary condenser. The product of one group is used for this, together with the drain from one or more heaters of another group.

This leaves the net output about 1,800 gal. per hour. It is absolutely fresh, showing no trace of salt on testing with silver nitrate. The coal consumption is about 1,700 lb. per hour, so that every gallon of fresh water discharged represents nearly a pound of coal —.94 lb.

The output of the plant on leaving the air pumps may be at once delivered overboard through hose manifolds on deck. Or it may be stored in tanks for future delivery. There are twenty-three storage tanks, nine in the forward and fourteen in the after hold. Their aggregate capacity is 131,545 gal. The main circulating pumps may be used to pump from these overboard or from one set to another. This allows quick delivery when a supply is on hand.

When under way the capacity of the main boilers is not great enough to admit operating the full plant. Evaporator room watches are the same as in the engine room. The engineer in charge has four assistants, one to each group. The plant works much steadier and distills a better quality of water after running 10 or 12 hours.

One serious source of trouble is the corrosion that occurs just above the waterline in the evaporators. Zinc plates are used, but seem to have little or no effect in checking the action. Many of the cast iron headers have already had to be renewed from this cause and angle irons and braces are rapidly eaten away. The feed valves on the shells are also attacked and require watching and frequent renewal.

As the first of its kind, this plant was necessarily more or less of an experiment. Several improvements might be made which would add greatly to its convenience and possibly to its efficiency. It was installed at the Norfolk Navy Yard in the fall of 1898 by the M. T. Davidson Steam Pump Works, of Brooklyn.

Since her arrival in the Philippines in May, 1899, the *Iris* has proved the most useful auxiliary ship of the Asiatic Squadron. She has a coal carrying capacity of 2,300 tons, besides stores and ammunition. Most of the time is spent around the Philippines, with occasional trips to China. She rendered good service to our fleet while anchored off Taku during the recent trouble.

New Line of Steamships.—The Northern Pacific Railroad Company announces that it will operate a line of steamships from Tacoma to Liverpool, via the Suez Canal. Seven of the ships to run in this service were formerly of the Glen Line.

Cunard Dividend.—The Cunard Steamship Company, Limited, has issued its report for the year 1900. The expenditures were: Working expenses, £937,572; repairs and renewals, £89,490; insurance, £46,797; profit and loss account, £538,080. Out of this last amount a dividend of 5 per cent per annum was declared. One of the stockholders stated that this favorable report was due to chartering the vessels during the South African war. The company has 26 ships of 126,102 gross tons.

An Instrument for Detecting Storms.—A new application of the coherer has been made by M. Tommasina for detecting atmospheric electrical discharges at great distances. The instrument invented is called the electro-radiophone, and is described in a paper read before the Academie des Sciences, of France. The instrument embodies the principle of the "auto-coherer" discovered by M. Tommasina, in connection with a telephone receiver and battery. In the glass tube of the conerer are two cylindrical carbons, almost touching in the center, and the space between them is filled with granulated carbon. Platinum wires are attached to the outer ends of the carbon sticks, the contents thoroughly dried and the tube sealed. Under the action of the electric waves the granules of carbon cohere, thereby greatly reducing the resistance across the space between the carbon terminals, and allowing the battery current to flow through the coherer and telephone receiver. When the waves cease the granules return to their original state, which is the unique property of this coherer. The tube is placed parallel to the axis of the receiver. The inventor states that in his experiments he heard a series of sounds in the telephone of a storm which was taking place beyond the horizon. In one case he observed a storm twelve hours before it passed over Intra, in Italy, where he had installed the apparatus.

REPORT OF TEST OF U. S. SUBMARINE BOAT HOLLAND.—II.

PAST PERFORMANCES OF THE HOLLAND.

While on the *Holland* I was permitted to look over her log books. These records extended over a period of at least one year. I could find no evidence that either the electric propelling motor or the gas engine had ever been previously in continuous operation for a period of six successive hours. It is extremely doubtful if the boat ever previously ran, under surface propulsion, a continuous run of over 30 miles.

I was informed that the boat was towed from New York to Washington when she was brought around to the latter city to be inspected by the Senate and House naval committees.

With the exception of running a few hours under her own motive power, she was towed from Washington to Newport, R. I. The tug *Josephine* towed her to New York and the U. S. tug *Osceola* towed her from New York to Newport.

After being at Newport several months the *Holland* was towed, with the exception of about 12 miles from that port to Annapolis, Md., the U. S. steam tug *Leyden* and the U. S. gunboat *Alvarado* being employed to tow her between Newport and Annapolis.

I have even been informed that when the *Holland* was at Washington for the benefit of the Navy Department and the naval committees a tug occasionally towed her to the points where she dived and maneuvered for the instruction of the Government officials.

VENTILATION.

For surface propulsion, barring accidents, the boat is well arranged for securing good ventilation. Directly over the gas engine is a ventilator, and in the base of this ventilator is an electric blower. The conning tower serves as an excellent air shaft. There is a second ventilator, so that it is possible to secure a good circulation in the hull. For surface work, therefore, only an accident to the gas engine could cause discomfort or danger to the occupants.

Under submarine conditions, however, different ventilation can be expected. The ventilators and hatches must of necessity be closed. Gasoline is a great searcher, and if there is a defective joint or weakness in the piping it will be found by this combustible. One of the resultant products of combustion of gasoline is carbonic oxide (carbon monoxide), a deadly poison. Since this gas is odorless, it is particularly dangerous by reason of its insidiousness. Although the gas engine will not be used for submarine work, yet an accident may happen which may cause the gasoline to leak, and in this manner the odorless deadly poisons may be formed.

A short personal experience of my own during this speed trial may show how it affects others than the regular crew. The first hour that I spent in the engine room of the *Holland* was an exceedingly trying one, for there was just enough odor from the gas to make me uncomfortable. Afterwards I became accustomed to existing conditions, and did not seem to notice any disagreeable odor for the rest of the day. The following morning, however, I not only had something of a headache, but for several hours experienced a nervous sensation which I have never undergone before. The crew, who were in the engine room about three times as long as I was, it is but fair to state, did not seem to be affected in any manner.

DEFECTS OF MECHANICAL DESIGN ARRANGEMENTS.

In using three distinct systems for securing mechanical energy the *Holland* has an inherent weakness. In this small boat of 75 tons, gasoline, electricity and compressed air are used for different purposes.

Gasoline is extremely liable to catch fire. At least one of its products of combustion is extremely dangerous to life. It is very attenuated, and, therefore, a great searcher. If there is a defective joint or pipe or leaky valve the gasoline will find it. When it is used in an engine that appliance should be in excellent condition. After the armature of the motor burnt out it became necessary to start the gas engine without the assistance of the electric motor. To secure the requisite amount of air for insuring an explosion at the start recourse was had to the reduced air pressure in the pipes. It took at least twelve minutes to start the engine in this way. During the effort there was a small discharge of gas into the hull from some improper working of the valve. Even from this small leakage the machinist in charge of the motor became very much distressed, and when he came on deck to overcome this faintness by securing fresh air, he appeared very pallid and not far from collapsing. This sight impressed forcibly upon my mind the danger of using gasoline.

In a boat of the character of the *Holland* it must be difficult to keep the electric motors in a high state of efficiency. The compartment must of necessity be damp, and therefore drops of water are likely to fall on every part of the dynamo. Salt water is likely to fall down the hatches and ventilators, thus impairing the ventilation. Through accident the boat is likely to sink at her dock, for this very mishap has occurred when the inventor was trying to sell the boat to the Government.

The air flasks may be an element of danger, since they are charged with pressure of 2,000 lb. The explosion of any one of these tanks would destroy the vessel. There are reducing valves for regulating this pressure, but any careless, inexperienced, or evil disposed person might cause a serious casualty to the boat by tampering with the reducing valves. These valves are so exposed that it will not be a difficult matter to tamper with them.

The gas engine is so closely installed to both the main and auxiliary motors that it will be a very difficult matter to do any extensive overhauling or make important repairs. In fact, the three appliances are so bunched together that it will take at least ten working days to line up the shafts for this little craft.

There are three sets of gearing. The gas engine is geared to the main shaft. The main motor is also geared to this shaft. The auxiliary motor is geared to a countershaft, which works the bilge pump and air compressor. The use of gearing on board any ship is at least inadvisable, for no matter how strong the hull is made there must be in a seaway some working of the vessel, and therefore the strain on the gear at times must be very great.

The noise in the engine room is a serious disadvantage. Since the gas engine is subjected to shock

rather than to steady pressure, and since it has tripping arrangements for admitting the gas, the engine itself makes considerable noise. The electric motor must not only be kept in readiness for backing purposes, but also for quickly starting the gas engine, and so there is noise from the motor's set of gearing. Since the compressor is kept in continuous operation to maintain the pressure in the air flask, there is noise from that gearing. There is noise from the gearing between the gas engine and the propeller shafts.

Any accident to the ignition battery would throw the gas engine out of operation, and it would appear that this may prove a serious weakness.

From the above it will be observed that the *Holland* has serious mechanical weaknesses. From each of the three motive powers—compressed air, gasoline and electricity—accident or danger, due to the conditions of installation, may happen at any time.

THE HOLLAND APPEARS TO HAVE NO UNUSUAL APPLIANCES.

The *Holland* appeared to me as a spindle shaped boat with very little freeboard. Even for the surface propulsion she need have no superstructure except the conning tower. It is extremely doubtful if she is much more visible under many conditions when she runs semi-submerged than when she runs as a submarine craft. It would be extremely difficult for any enemy to detect her, but it would also be extremely difficult for any enemy to sight any gasoline or electrical launch that had a spindle hull.

Every appliance that was installed was either a commercial auxiliary, or else it was of such a nature that a substitute could be secured from any large supply house.

I not only looked for, but made inquiry for, any distinctive invention. There was pointed out to me a tank constructed between two frames, which was said to have been one of the special inventions granted by the Patent Office. This simple compensating tank is filled with water when one of the torpedoes is removed. A hydrostatic piston was attached to the steering engines, but this appliance has been in common use. This piston was said to have been a distinctive feature of the boat.

The firm plate of the maker was on most of the auxiliaries, and there appeared no evidence that any of them were special contrivances. There was reason to believe that during the past two years there have been marked improvements in the mechanical details of construction, for numerous changes were pointed out which have proved beneficial.

GENERAL REMARKS.

Previous to the speed endurance trial the *Holland* had been at the Naval Academy for about two months. She was probably in as serviceable a condition during the trial as she had ever been before. She had made numerous short runs at Annapolis, and quite a number of the officers of the Academy had accompanied Lieutenant Caldwell in his dives. Some new castings had been fitted, and, so far as the design and conditions would permit, various adjustments and overhaulings had been made.

The Navy crew of the *Holland* had a great pride in the boat, and they had done everything that the resources of the Academy would permit and their observation would suggest to make the boat more efficient as well as comfortable. Under the direction of the commanding officer of the *Holland* there had been fitted a grating deck, which was found a very great convenience. If it had not been for this improvement alone it is doubtful if the *Holland* crew could have stood as long a watch as they did after leaving Annapolis.

From what I saw after nine successive hours of observation, and from an examination of the machinery of the *Holland* after she reached Norfolk, I am convinced that it was through the skill, endurance and pluck of the commanding officer and the crew of the *Holland* that the boat performed as well as she did. There were several of the crew, besides Lieutenant Caldwell, who were practically on duty continuously for eighteen hours after leaving Annapolis. During that period they had no cooked meals, but ate from a lunch basket, and there was not one of them who could assume even a comfortable position in carrying on his work. The atmosphere was very humid, and with a low temperature there must of necessity have been depressing conditions. The machinist operating the gas engine and the electrician who was in charge of the motors were almost continuously on duty for thirty hours after leaving the Naval Academy, for during the first three stoppages they had to remain at their posts to make adjustments and to charge the storage battery.

Personally, I am satisfied that no civilian crew could or would have done better, and therefore the Holland Company could not have secured better results if they had been permitted to send experts on board.

In conclusion, I desire that the Bureau would express in some official manner its appreciation of the interest Lieutenant Caldwell took in securing for the Bureau the general information called for.

The following abstract is given of the report of the commanding officer, Lieut. H. H. Caldwell:

REPORT OF LIEUT. H. H. CALDWELL.

The entire run from Annapolis Harbor to alongside the wharf at this yard was under the gas engine and without any assistance.

Got under way and started ahead under gas engine at 1.35 P. M., January 8, followed by the U. S. tug *Standish* as convoy; Lieut. R. Z. Johnston as passenger. At 6.15 P. M., off Sharp Island light, stopped to cool bearing of driven gear of motor (running as an idler) which had heated. Started ahead at 7.04 P. M.

Stopped at 4.35 A. M. to replace forward igniter, the packing of which had blown out. Directed *Standish* to anchor and secured astern of her to recharge storage battery, which had become much run down from the use of a new electric heater. Ran gas engine on motor, charging battery, for four hours. The use of the heater was discontinued, it not being necessary.

At 11.02 A. M. got under way and continued run down the bay. Lieut. Commdr. J. R. Edwards and Lieut. R. Z. Johnston as passengers. At 12.30 P. M. the after main shaft bearing became heated; stopped to cool it. At 1.30, in attempting to start gas engine with motor, it was discovered that an armature bar of the latter was burnt out, disabling the motor. This accident has occurred several times since the boat has been

under my charge and before, and is probably due to some inherent defect in the insulation. This armature has been condemned, and a new one will shortly be installed in its place.

Although the boat was now without means of reversing, it was decided to continue the run, and at 2.35 P. M. started the gas engine with the mixture and stood down the bay, followed by the *Standish.*

At 7.30 P. M., off New Point Comfort light, directed the *Standish* to anchor for the night and secured astern of her.

At 8.20 A. M., January 10, got under way under gas engine and stood down the bay, through Hampton Roads and up Elizabeth River, followed by the *Standish,* Lieut. F. P. Baldwin as passenger. At 2 P. M. secured alongside wharf at navy yard.

Lieut. Commdr. Edwards was carried as passenger under detail from the Department for the purpose of collecting data in regard to cruising radius. Lieutenants Baldwin and Johnston were detailed by the Superintendent of the Naval Academy for instruction.

The behavior of the boat and of all mechanisms was excellent in every respect, with the exceptions noted. The heating of the bearings was probably due to the shaft being somewhat out of line, and it is recommended that it be lined up when the new armature is installed. Some apprehension had been felt that the air in the boat would become bad after running the gas engine so long, but no inconvenience from that source was experienced.

DATA.

Distance run, 145 knots.
Time under way, 25 hours 36 minutes.
Average speed, 5.67 knots.
Maximum speed, 7 knots.
Consumption of gasoline for propulsion, 125 gal.
Consumption of gasoline for charging battery, 20 gal.
Capacity of gasoline tank, 1,300 gal.
Reserve capacity (ballast tanks), 3,500 gal. (approximately).
Consumption of engine oil, 12 gal.
The air storage is comprised in three sets of flasks (each of about 12 cu. ft. capacity) with air at a pressure of 2,100 lb. per sq in. For convenience in comparing supply with consumption this is referred to as 6,300 lb. of air. The compressor can raise the pressure in any one set of flasks about 350 lb. per hour. Using this notation:
Amount of air in flasks at beginning of run, 6,300 lb.
Air compressed during run, 8,850 lb.
Air remaining at end of run, 2,600 lb.
Air used during run, 12,500 lb.
Average consumption of air per hour for steering engine and whistle, 488 lb
Voltage on battery at beginning of run, 126.
Voltage at beginning of recharging, January 9, 109.
Voltage at end of recharging, 124.
Voltage at end of run, 120.
Maximum temperature in boat (engine compartment, engine running), 60 deg. Fahr.
Minimum temperature in boat, 45 deg Fahr.
Weather, generally fair.
Wind, moderate, to light southerly breeze.
Sea, generally choppy.
Draught, 8 ft. 6 in.
Condition of bottom, foul.
Pitching and rolling, not noticeable.

WIRELESS TELEGRAPHY.—The Cunard Steamship Company contemplates fitting an instalment of the Marconi Wireless Telegraphy System on board its transatlantic ships. The company's experts have examined the system, and it is understood that some improvements may be necessary before all the possibilities of the system can be fully developed.

UNITED STATES TORPEDO BOAT DESTROYERS LAWRENCE AND MACDONOUGH.

Of the sixteen torpedo boat destroyers appropriated for by Congress in 1898, there are, we believe, but two under construction, the plans for which have been furnished in their entirety by the builders. These boats are the destroyers *Lawrence* and *Macdonough,* under construction at the yard of the Fore River Ship & Engine Co., Quincy, Mass. These boats were launched late last year and are now nearing completion.

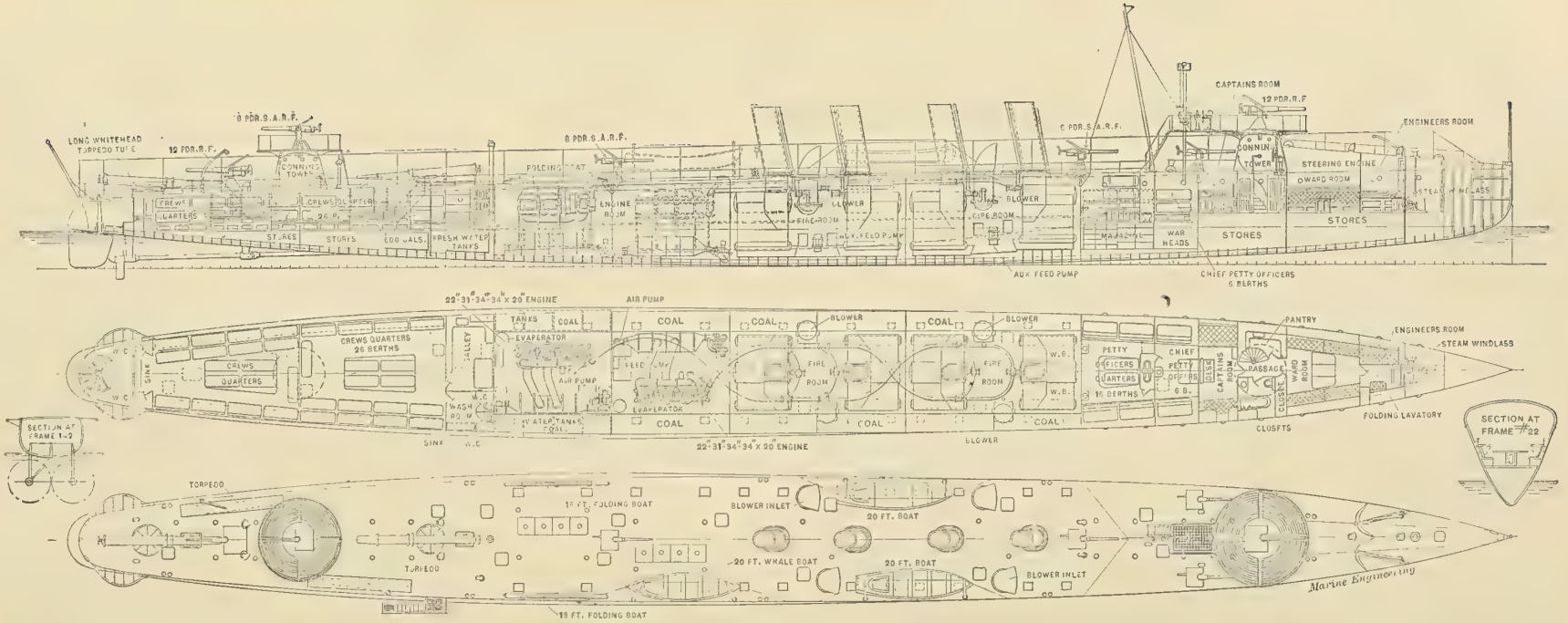
In the accompanying plans of these vessels there will be noted many differences from the designs which were furnished to contractors by the Government. Their general dimensions are: Length over all, 246 ft.; length on waterline, 240 ft. 10 in.; beam extreme, 22 ft. 3 in.; draft, mean, 6 ft. 1 1-2 in.; displacement, 400 tons; full load displacement, 489 tons. They are built of mild steel and galvanized to 1 ft. above the normal waterline. Each is divided into ten water tight compartments, four of which are used for the boilers and engines. The coal bunkers are also water tight, being fitted with water tight sliding doors in each fire room. The compartment forward of the boiler rooms is finished in hard wood, and is reserved for the quarters of petty officers, and forward of that are the commissioned officers' quarters. The joiner work in all quarters, and also all the non-portable furniture, is of quartered butternut, treated by patent process, rendering it absolutely fire proof. The flat keel plates are 12 lb. per square foot (5-16 in.), and the vertical 15 lb. (3-8 in.), all double strapped and treble riveted. The frames are 20 in. centers, and are bulb angles, 3 in. by 3-4 in. by 3.8 lb. in boiler and engine rooms, and 2 1-2 in. by 1 1-2 in. by 2.66 lb. at the ends. The deck beams are bulb angles of 2 1-2 in. by 1 1-2 in. by 2.66 lb, with a crown of 10 in. at the midship length. A stringer plate of 12 lb. nickel steel is worked at the ends of the deck beams, at the sides, for a distance of 100 ft. amidships, tapered and reduced in thickness at the ends. The general thickness of the deck plating is 6 lb. per sq. ft., and shell plating 8 lb.

Their armament will consist of two 18-in. Whitehead torpedo tubes, located on the after deck, one forward and one aft of the after conning tower. Each tube has a stowage case for one extra torpedo; also a crane and handling gear. Two 12-pdrs. rapid fire guns are carried, one on the forward conning tower and one on the after deck, and five 6-pdrs., one on the after tower, two over bulkhead No. 32, and two amidships on deck at bulkheads Nos. 44 and 62.

The destroyers are to carry at their davits one whale boat 20 ft. long, two cutters 20 ft., and two folding boats of canvas.

The bridge deck is at the level and aft of the forward conning tower, and is fitted with steering wheel, compass and indicators to and from each engine room. Above this is a platform for a 5,000 C. P. searchlight. The platform and all fittings are of brass, this being necessary to avoid deviation of the compass below.

The steering engine is located in the forward con-



INBOARD PROFILE AND PLANS OF U. S. TORPEDO BOAT DESTROYERS LAWRENCE AND MACDONOUGH.

ning tower, and is of the most improved type, and can be operated either from the tower or bridge.

These boats are expected to attain a trial speed of 30 knots for two hours, under the terms of the contract.

The engines are of the twin screw, vertical inverted, four cylinder, four crank, triple expansion type, with cylinders 22 in., 31 in. and (2) 34 in. dia., and 20 in. stroke. The collective horsepower of each boat is estimated at 8,400 I. H. P. when turning 320 revolutions per minute. Special care has been taken in design to secure minimum weight with maximum strength. Hollow forgings of nickel steel have been used where possible. The cylinders and cylinder heads are of cast gun iron, the valve ports being cast in one piece with the heads and then bored, and fitted with liners, of the same material, and ground in place to perfect alignment. The pistons are steel forgings and turned solid, no followers being used, the rings are in segments and held out in place by steel springs. The piston and connecting rods are hollow nickel steel forgings, oil tempered and annealed. The framing is composed of ten forged steel columns, thoroughly braced by diagonal and other braces, possessing great strength, combined with lightness. The guides are hollow castings of gun iron, fitted with a water service, the backing gibs being carbon steel. The crank shaft is made in two sections, and is also oil tempered and annealed. Each shaft is 8 in. in dia., with a 4 in. hole through both shaft and pin. The cavity in the pins is utilized as an oiling device, being filled with grease, which is thrown out by centrifugal force through a small hole in the pin. The cranks are set at an angle of 90 deg., the high and intermediate being opposite, as are also the first and second low pressure, insuring a balance of reciprocating parts and reducing vibration. The engines are fitted with single ported piston valves, operated by a side shaft, which in turn is driven from the main shaft by a set of three nickel steel gears. The reverse motion is obtained by a right and left hand spiral sleeve, worked by hand and steam gear of improved design. The bearings of the cross heads, crank pins, and other important parts are of the naval standard composition lined with anti-friction metal, and all fitted with automatic oiling devices.

The thrust, line, and propeller shafts are also made of oil tempered nickel steel, 7 3-4 in. dia., with a 4 in.

axial hole their entire length. The propellers are three bladed, of manganese bronze, with a diameter of 6 ft. 6 in., and a pitch of about 12 ft.

Each engine is supplied with a separate condenser, built entirely of copper and composition, and having a cooling surface of 3,800 sq. ft., measured on the outside of the tubes. The tubes are made of the same material, and the interior of the whole is tinned. The circulating water is supplied to them while the boat is in motion by a projection through the hull, and by an independent engine and centrifugal pump when at rest. This pump is also utilized as a bilge suction in case of emergency, and is capable of delivering 2,000 gallons per minute from the bilge to the sea.

The engine rooms being entirely independent of each other, are each fitted with a duplex boiler feed pump, delivering into a main, which can be used to supply any of the four boilers; also a fire and bilge pump. The bilge is also taken care of by a 2 in. steam ejector in each water tight compartment.

The air pumps are also independent, and are triple cylinder power pumps, driven by a 4 1-2 in. by 4 1-2 in. by 4 in. double engine through a train of gears. Beside these auxiliaries in the engine rooms, there are installed evaporators capable of supplying 200 gallons of fresh water per hour; an air compressor for the torpedoes, and an electric plant of 5 K. W. capacity, which furnishes light and electric power for the entire vessel.

There are two boilers, of the builders' water tube type, in each water tight compartment, forward of the engine rooms and aft of the officers' quarters. Each of these boilers has a grate surface of about 80 sq. ft., and heating surface of 4,500 sq. ft., and is built for a working pressure of 260 lb. per square inch. The tubes are seamless drawn steel, 1 1-8 in. outside diameter, each boiler containing about 2,000. The drums are lap welded throughout, with extra thickness of material where the tubes enter, and are 42 in. and 19 in. in diameter, and fitted with a manhole of sufficient size to allow entrance for examination and cleaning. They are supplied with automatic safety stop valves and feed regulators. The casings are sheet steel, lined with fire brick and non-conducting material, and are sectional, allowing them to be easily removed, besides having doors where necessary for cleaning.

An auxiliary feed pump is fitted in each boiler room to deliver into the same pipe as the main feed pumps, and the system of piping is such that it is next to impossible to entirely disable the machinery through the breaking of a pipe. The boilers are fired under the closed fire room system. There are also two 48 in. blowers in each fire room, each run by 4 1-2 in. by 4 in. single engine.

These boats, when they leave the builders' hands, will be furnished complete and equipped ready for service.

Trial of the Torpedo Boat "Bailey."—The official trial trip of the *Bailey*, built by the Gas Engine & Power Co. and Chas. L. Seabury Co., Consolidated, was run on Long Island Sound on April 25, and, according to press dispatches, a speed of 30.2 knots was maintained for two hours.

DESCRIPTION OF THE MANUFACTURE OF SEAMLESS STEEL BOILER TUBES.

BY C. A. M'ALLISTER, FIRST ASSISTANT ENGINEER, U. S. R. C. S.

Since the introduction of the tubular boiler the subject of tubes has been one of vital importance to the marine engineer, and the advent of the water tube boiler for use on shipboard has increased this importance. Welded iron tubes were almost universally used in the earlier days, but the employment of higher steam pressures created a demand for a superior metal for this purpose. Consequently, in the early nineties the prevailing practice of the Navy, and of the merchant service to a large extent, was to use lap welded steel tubes. The experience with this material proved somewhat disastrous, for, in order to obtain a grade of steel which could be successfully welded, manufacturers were compelled to use billets, which were taken from the tops of ingots as cast, to get material of sufficient porosity to weld properly. However, the welded steel tube era in boiler construction was of but short duration for marine purposes. It was found that steel of the right grade for welding was easily pitted and corroded when put in use. Indeed, so rapidly did this pitting and corrosion take place, that, in one instance at least (that of the cruiser *Detroit*), every boiler had to be retubed after less than six months of service. A few experiences similar to the one quoted caused a quick return to charcoal iron tubes.

About this time seamless drawn steel tubes began to attract the attention of designers of marine boilers. They had been used successfully in some small tubular boilers, but had not been used for Scotch boilers. The naval authorities, foreseeing the advantages of this type of tube, began to investigate the matter, and, with this as an incentive, American manufacturers put forth their best efforts to produce tubes of such diameters and qualities as to fulfill the Navy requirements. The results have been highly satisfactory, both to manufacturer and consumer, as to-day all tubes used in the construction of boilers for the Navy, whether of the fire tube or water tube type, are of seamless drawn steel. The large orders of these tubes incident to their adoption for Naval purposes have enabled manufacturers to produce and sell seamless steel tubes at about the same price as that of welded iron tubes. The merchant service, also, is making extensive use of the seamless tubes.

As comparatively little has been written concerning the method of manufacturing this product, the following brief description may be of interest. As the ends of nearly all tubes must be either beaded over, or expanded, a soft grade or low carbon steel is required in the manufacture. The steel best suited for this purpose is that taken from the bottom half of the ingot, and showing a chemical constituency approximately as follows: Carbon, .17 of one per cent; manganese, .45; sulphur not exceeding .023, and phosphorus not exceeding .01 per cent. When made from steel of this analysis, samples cut from the finished tubes show a tensile strength of between 48,000 and 56,000

lbs. per sq. in., and an elongation in a length of 8 in. varying from 25 to 30 per cent.

The steel used in most of the tube mills is made by the basic open hearth process, and is received from the steel mills in round billets 4 in. dia. and from 8 to 10 ft. in length. The first step in the manufacture is to heat the billets to a cherry red, and to "hot saw" them into such lengths as will provide sufficient material for the size of tubes ordered.

These short billets are then heated to a white heat, and taken to the piercing mill. In this mill they are revolved rapidly and driven up against the piercer, which also revolves, but at a slower rate of speed. A longitudinal hole about 1 in. dia. is thus pierced through the center of the billet. This process can be performed successfully on billets as long as 12 or 14 ft., but the ordinary lengths are from 2 to 5 ft. At the same heat the billet is next run over an expander, which increases the diameter of the hole to a size suitable for the rolling process. After being thus pierced and expanded, the pieces are known as "hollow billets," and are ready for the hot rolling process. In the newer mills the billets are taken to the rolls before cooling off. The rolls are similar to the ordinary rolls used in making rods, but tubes must be rolled in only one direction, and then passed back over the top of the rolls, as they are run over a mandrel, which insures a cylindrical inner surface. They are usually given from twelve to fourteen passes through the rolls, which process reduces them to a diameter about 1-2 in. larger than the finished tube is required to be, and from four to six gauges (B. W. G.) thicker. At each pass through the rolls, the operators give the hot tube a quarter of a turn, so that all parts may receive an equal amount of working.

After going through the rolls, one end of each tube is crushed down on all sides, or "pointed" to insure a solid grip for the pliers or tongs on the cold drawing benches.

Having been heated to a white heat, these tubes are covered with a heavy mill scale, which, if not removed, would cause considerable trouble and produce rough surfaces on the tubes when cold drawn. Therefore, before cold drawing, they are immersed in a warm bath of dilute sulphuric acid, which, to a considerable extent, removes the objectionable scale. To provide for the proper lubrication of the surfaces when the tube is drawn through the dies, the pickling is followed by an immersion in a mixture of tallow and flour dissolved in warm water. This process is known in the mill vernacular as "doping." The tubes are placed in an oven where the "dope" is dried on, and a complete and uniform distribution of this lubricant thus insured. They are then ready for the cold drawing bench, which consists of a horizontal framework about 2 ft. in height, upon which is a rigid support for the dies. The power for the drawing is furnished through an endless chain, constructed of flat links three or four links in width. This chain is kept in constant motion at a uniform rate of speed. The pointed end of the tube is run through the die, and at the same time the mandrel on the end of a long rod is run through the tube, so that it comes directly inside the die. The end of the rod is fastened to a rigid support on the outer end of the bench, thus holding the mandrel in the right position relative to the die during the drawing. The pliers, or gripping tongs, are then fastened to the pointed end of the tube, and the hooks on the pliers are dropped into the spaces between the links of the endless chain. The tube is thus slowly drawn through the die and over the mandrel, gradually increasing in length, and decreasing in diameter and thickness. This process is repeated five or six times, until the tube is reduced to the required diameter and thickness. The tubes are annealed after each of these cold passes, and again put through the pickling and doping processes, except at the finishing pass, when they are immersed in oil, instead of "dope," which gives them a bright, silvery surface. The object of annealing the tubes after each cold pass is to remove the local strains incident to the drawing. If, during any of these cold passes, the slightest scratch or other defect develops in either the die or mandrel, the surfaces of the tubes will be seamed or scratched throughout their entire length. It is, therefore, essential that the dies and mandrels be given a careful inspection after each pass, so that any defect may be remedied. As the men in the bench room are paid on the tonnage system, or in proportion to the output, they naturally grow careless in watching the dies, but if the proper attention is given, tubes can be produced absolutely smooth on both surfaces. Should such defects as snakes, seams, or laps exist in the billet, they will almost invariably show in the finished tube, and great care must be taken in examining the tubes before the final annealing. The usual practice of the inspector is to rub over the entire length of each tube with a piece of waste, the existence of a sliver, lap or tear being then easily detected by the lodging of pieces of the waste at the defective parts. Scratches on the inside are discovered by running the finger nail around the inner circumference, and if any scratches are deep enough to catch the nail, the tube should be rejected.

After the tubes have passed the surface inspection, they are cut off in a lathe to the lengths required, and gauged with a micrometer. They are generally found to be quite uniform in thickness, but frequently one is discovered to be eccentric, or below gauge, and is therefore rejected. The requisite number of test pieces are cut off from the ends of tubes selected at random, usually to represent lots of 100 tubes each, and these pieces are annealed in the same charge with the tubes which they represent. After being annealed, every tube is subjected to an internal hydrostatic pressure of from 1,200 to 1,500 lb. per sq. in., whether required by specifications or not, thus insuring perfect tubes, so far as strength is concerned.

The following are the requirements for all seamless cold drawn steel tubes furnished to the Government:

TESTS FOR SEAMLESS COLD DRAWN STEEL BOILER TUBES.

1. These tubes will be made of low carbon mild steel, of the best composition for the purpose, and uniform in quality and grade.

2. The tubes will be inspected for surface defects after being straightened, but before being

cut to length, and they must be free from rust, scale, sand marks, laminations, hard spots, checks, cracks, and injurious defects generally.

3. The pointed end of the tubes will then be cut off, trimmed, and gauged, and each tube at the thinnest point must be up to the gauge ordered. The interior of each tube will be inspected at the same time, and any that are badly seamed or scratched in the drawing will be rejected.

4. The tubes which have passed the above inspection will then be cut to the lengths ordered and gauged at the end last cut off, and each tube at the thinnest point must be up to the gauge ordered. A sufficient number of test tubes, selected and stamped by the engineer inspector, will be cut about 4 in. longer than ordered.

5. If the tube ends are flanged, swaged down, swelled, upset, or re-enforced, they will be inspected afterwards to see that no material damage has been done by this process.

6. Each tube shall be subjected to 1,000 lb. internal hydrostatic pressure without showing weakness or defects.

7. All tubes must be annealed in retorts or an approved furnace in which the flame from the fuel used in heating the annealing furnace does not strike the tubes. One or more of the stamped test tubes will be placed in the center of each retort or middle of each furnace charge, one for each twenty-five tubes or less. The charge of each retort or furnace will be numbered and kept separate until the tests are completed. The test tubes will be given the same number as the charge with which they are annealed, so that if it is found after testing that any lot is not soft enough, it may be reannealed.

8. The annealed tubes will then be divided into lots of not more than one hundred each, and the engineer inspector will subject four of the stamped test tubes belonging to each lot to the following tests:

(*a*) The end of one test tube must stand being flattened by hammering until the sides are brought parallel with a curve on the insides at the ends not greater in diameter than twice the thickness of the metal in tne tube without showing cracks or flaws.

(*b*) One test tube shall have a piece one (1) in. long cut from the end, which must stand crushing in the direction of its axis under a hammer until shortened to one-half (1-2) in. without showing cracks or flaws.

(*c*) The end of one test tube, cold, shall have a smooth taper pin, taper one and one-half (1 1-2) in. to the foot, driven into it until the end of the piece stretches one and one-eighth (1 1-8) times the original diameter without showing cracks or flaws.

(*d*) The end of one test tube, heated to a bright cherry red, in daylight, shall have a smooth taper pin, taper one and one-half (1 1-2) in. to the foot, at a dull red heat, in daylight, driven into it until it stretches to one and one-eighth (1 1-8) times its original diameter.

If any one of those tubes selected for test fails, that tube will be rejected, and the inspector will select two extra tubes from the same lot and put them through the same test as the tube that failed, and both of these tubes must be found satisfactory in order that the lot may be passed. The failure to pass satisfactorily any one of the tests marked (*a*), (*b*), (*c*), (*d*), will reject the lot.

9. The failure of a large proportion of the tubes selected to stand any of the above specified tests in a satisfactory manner will render the whole delivery liable to rejection.

10. All tubes rejected will be marked in such a manner as to prevent their being presented a second time for inspection.

11. Each tube shall be stenciled with the name of the vessel for which intended, with the word "Seamless," and the maker's name, also with the inspector's identification stamp.

Tubes which fulfill the above requirements can be relied upon absolutely for all service put upon them in marine boilers. As to the endurance of this type of tube, it has hardly been used in marine boilers for a sufficient time to form an estimate of its longevity. The writer has, however, seen samples cut from the boiler of a locomotive, which, although covered with scale due to the minerals in the feed water, still maintained under the scale the hard, shiny surface put upon it at the tube mill. It would thus appear that the ideal boiler tube has been obtained, although it would seem that for marine purposes, 5 per cent nickel steel might be an improvement over the carbon steel now in use, as the former is tougher and less liable to corrode.

A few words as to the uses, other than for boiler purposes, to which seamless drawn steel tubing can be put in marine work, will not be amiss. These tubes can be, and are, drawn of any thickness required, and of any diameter from 1-8 in. to 6 in. The section of drawn tubing is not entirely confined to the circular, for, as a matter of fact, almost any section, be it rectangular, triangular, elliptical, or otherwise, can be drawn as readily as is the circular. Tubes have been drawn circular in section on the outside and hexagonal on the inside, or vice versa. For short lengths of from 12 to 20 in., seamless tubes can be furnished tapered, say with a 1 in. dia. at one end, and 1-2 in. dia. at the other. They are readily bent into almost any conceivable shape, and, if necessary, can be made square on one end and round on the other. In the torpedo boats now building, steam pipes of seamless drawn steel are being furnished with an internal diameter up to and including 6 in.

A further important field in which seamless drawn tubes could be employed, would be in making them to gas pipe sizes, and using them where iron steam and exhaust pipes are now used on board ship, as in making connections to pumps and other auxiliaries and for steam heating purposes. They would be far superior for these uses to the common lap and butt welded iron pipe now employed. The manufacturers are perfectly willing to draw tubes to gas pipe sizes, should the demand warrant the expense of changing their dies and mandrels.

MARINE ENGINEERING

PUBLISHED MONTHLY

BY

MARINE ENGINEERING

309 Broadway, New York.

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Treasurer and General Manager.

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Philadelphia, Pa., Mach'y Dept., The Bourse, S. W. ANNESS.
Detroit, Mich., Hodges Building, L. L. CLINE.
Boston, Mass., 170 Summer St., S. I. CARPENTER.

TERMS OF SUBSCRIPTION,

	Per Year.	Per Copy.
United States, Canada, and Mexico.....	$2 00	20 cents.
Other countries in Postal Union.....	2.50	25 cents.

Entered at New York Post Office as second class matter.

Notice to Advertisers.

Changes to be made in copy, or in orders for advertisements, must be in our hands not later than the 15th of the month, to insure the carrying out of such instructions in the issue of the month following.

THE recent fire on the Munson Line steamer *Olinda*, and her action in nearly capsizing when water was pumped into the cargo hold, calls forcible attention to the influence of liquid cargo on stability. It is a fact which is too little understood, that the effective point of application of the weight of a liquid with a free surface is considerably above its own center of gravity. That is, when water is pumped into a hold, the effect on the stability is the same as though an equal weight of solid cargo were loaded on to the main or upper deck for example. The reasons for this are mathematical and beyond the range of our present discussion, but if the fact be admitted, it is clearly seen that for a vessel with a moderately small metacentric height, or in other words, with but moderate stability to begin with, it may easily result that the addition of free water in the hold may result in destroying the margin of stability and in placing the vessel in a position where she will capsize outright or at least take a dangerous list before equilibrium is found. To judge from the published reports, the *Olinda* seems to have been ready to turn turtle, and was only prevented by the lines which were gotten out, holding her to the pier. A better understanding of these principles would have enabled those in charge to foresee the possibility of such a result, and to take appropriate measures in advance. In the actual case no serious result followed, but the margin of safety was perhaps small, and a little greater promptness on the part of the vessel or slowness on the part of those in charge in getting out lines, might have led to a quite different result. Forewarned is forearmed.

WE commend to the careful attention of our readers the article by Mr. R. E. Horton published elsewhere in this issue on American canal problems. As shown by the author, the fundamental feature of the United States, which makes the problem of canals of such large interest, is its compact and approximately rectangular form, with no deep water communication from the interior of the country to the seaboard. The inland producers naturally wish to sell to the best buyer, and object to being shut off from the open markets of the world by the mere accident of geographical location. Citizens of the State of New York may have been led to think that the question of the deep water way to the Great Lakes and interior of the country was one in which their interests were paramount, and that it should be settled, having chiefly in view the needs and welfare of this State. Mr. Horton shows plainly how much wider is in reality the question, and how necessary it is that it should be regarded indeed from the national rather than from the sectional point of view. Just what turn matters may take remains for the future to show. It seems quite sure, however, that New York State alone will not undertake the construction of anything approaching the dimensions of an adequate ship canal, while the recent action of her Legislatures in regard to the barge canal bill leaves it uncertain what her final attitude will be. In the meantime the construction of an Isthmian canal is more prominently in the public eye, and if at an early session of Congress such a water way should be authorized and completed within reasonable time, it seems not improbable that there will be an overwhelming pressure from our Middle West for the Mississippi outlet in order to gain the quickest possible route to the Orient and South American trade. We believe that the people of the State of New York will do well to consider that when these problems of deep water

way outlet from the interior of the country begin to attract the serious attention of the American people, it will not be the needs of this State which will receive sole consideration, and assuming an Isthmian canal constructed, it will be for the people at large to say which of the two they wish: a deep water way outlet to the Atlantic, or to the Gulf of Mexico; and if both, which they desire the first. In the meantime our friends in Canada are by no means idle, and it is quite within the limits of the possible that the Georgian Bay St. Lawrence ship canal may in the near future be something more than a route on paper. If that day should soon come, New York will be forced into action of one kind or another which shall enable her to compete with the Canadian route, or else suffer the most serious losses in her shipping business.

IN a recent contemporary, we have seen reference to the old question of whether boiler heating surface should be measured on the fire or the water side.

The question is one relating to the flow of heat from the hot gas through a metal partition and into a liquid. Now the resistance to such a flow of heat consists of three items, the resistance to the absorption on the fire side, the resistance to the transmission through the metal itself and the resistance to the emission or giving out of the heat on the water side. It is well established that the second item, the resistance of the metal itself, is too small to be of any real importance, and that the resistance really consists therefore of the first and last items. The question of measuring heating surface depends, therefore, on which of these is of the greater importance, or to which is due the limitation to the flow of heat. In regard to this point it is known that with clean heating surface on both sides, the temperature of the plate all the way through is substantially that of the water. In other words, the heat seems to escape from the metal more readily than it enters, and it follows that the limitation to the flow of the heat is met with on the fire rather than on the water side, and in consequence the former is a more correct measure than the latter of the heating surface of a boiler. It is further shown readily that the difference between the two may vary from nothing when the plates are flat to some fifteen per cent or more with small tubes.

So far the scientific theory carries us, and the way is clear. When, however we ask for what purpose boiler heating surface is measured, we find that whether the surface is measured on the fire or water side becomes of small importance in comparison with several other considerations which enter into the question of the practical use of such information. The chief reason for measuring the heating surface of a boiler is to make possible a relation between this item and the performance or capacity of the boiler. Such a relation can only be found by experience, and when once determined for varying sets of conditions, such information may be made use of for purposes of design. This is then the real purpose of such relations, and the vitally important point in their use is the assumption, always implied, that the conditions from which the relations are drawn are similar to those expected in the proposed design, and that furthermore they are expressed and used in a similar manner.

If, therefore, the data which the designer expects to use expresses the relation between capacity and heating surface, with the latter measured on the water side, it is important that it be used in the same way, and that the heating surface of the proposed boiler be measured on the water side also, and similarily, of course, if in the original data the heating surface is measured on the fire side. In other words, it is far more important to use the data always with the same significance than that it should be in the abstract measured on either one side or the other.

Still another point. When we realize that according to the condition of the heating surface and to the rate at which the combustion is forced, the value of the heating surface per square foot will undergo changes of several hundred or even up to 1,000 per cent, it is again quite evident that it is more important to have full information regarding the conditions of the combustion and the heating surfaces than to know whether the heating surface was measured on one side or the other. In other words, a layer of soot on the fire side, or of scale or more especially oil and scale on the water side, or again varying rates of combustion, may any one of them cause a difference in value many times greater than that between the two ways of measuring the surface.

The latter is a point worthy indeed of proper attention, but in the treatment of engineering questions first attention must be paid to the factors of chief importance, and we must avoid straining out the gnats and swallowing the camel.

IMPROVED APPARATUS.

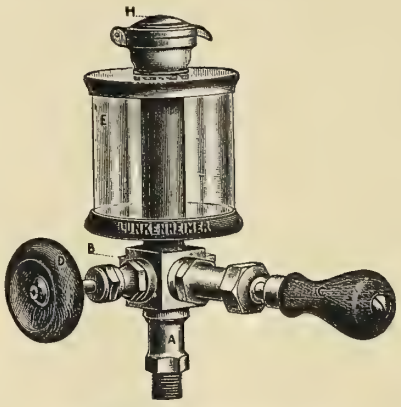
Grate and Bearer Bar.

This is one of the many special forms of shaking grate and bearer bar.

It is claimed for this bar that, due to its peculiar construction, with the same draft and other conditions, more coal can be burned per square foot of grate than with other forms; also that the use of the prick bar is practically obviated, and the work of slicing materially reduced. Each bar works independently, thus allowing of special treatment of any part of the fire. It is also claimed that the corrugated form of the surface is such as to prevent clinker from becoming attached to the bar, and that as soon as clinker or ash may begin to form the distribution of air is such as to prevent overheating, and thus the life of the bar is prolonged. The clinker not becoming firmly attached to the bar also allows it to be more easily disposed of, and the fireman is the more disposed to use the shaking movement, not becoming discouraged by the compacting together of a mass of clinker and the consequent jamming of the bars. It is also claimed with this design of bar that an unusually large air space can be provided, thus making them suitable for forced draft, and insuring a more complete protection of the bar from danger of overheating. This bar is manufactured by the St. John Grate Bar Co., of Philadelphia.

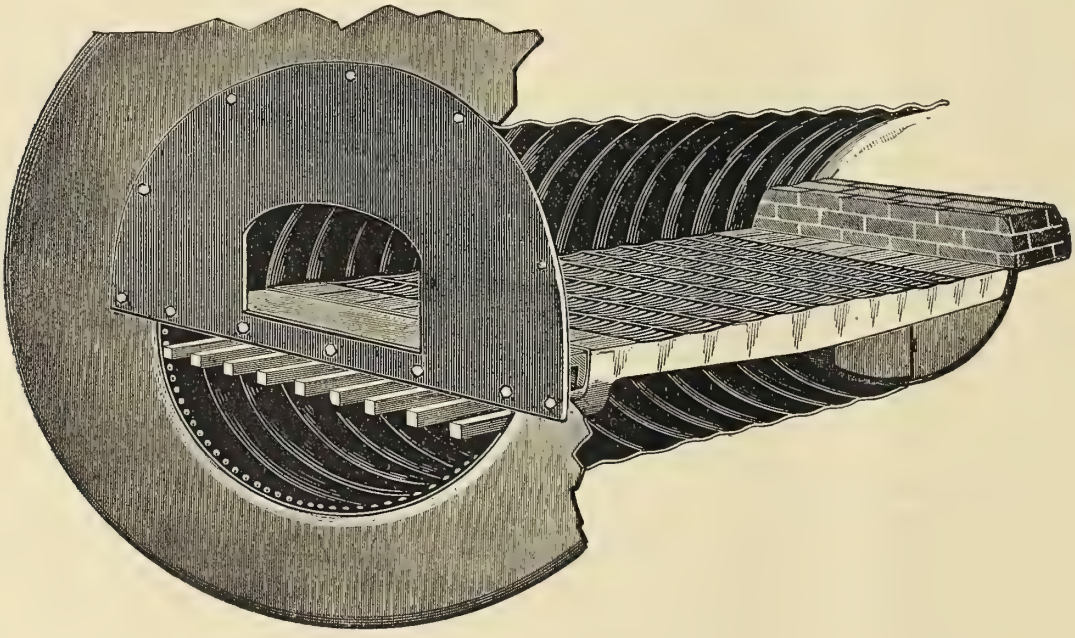
Hand Oil Pump.

The form of oil pump shown in the engraving is preferred by some users to the lever pattern. The transposing plug (*B*) and shank (*A*), which are interchangeable. This is an improvement over other makes of this type of oil pump, as it permits of adapting the



LUNKENHEIMER HAND OIL PUMP.

pump to meet any requirements of position: *i. e.*, it can be connected either into the steam pipe or steam chest. As shown, it is arranged for vertical connection. The filling hole is closed by a hinged cap, which keeps out dust and dirt, and in addition, there is a removable wire gauze strainer to insure clean oil. The plunger is well made and very durable. All parts about the pump are heavy, large, well constructed, and not liable to get out of order easily. They are well designed and finished and present a handsome and ornamental appearance. Where required, these pumps can



ST. JOHN GRATE AND BEARER BAR.

Universal hand oil pump is easy to attach, fill and operate, and works well under high pressure. It can be made to attach either vertically or horizontally by be furnished with brass instead of glass body, as shown. This pump is manufactured by the Lunkenheimer Co., Cincinnati, O.

THE MARINE STEAM ENGINE.

OVERHAULING AND REPAIRS.

BY DR. WILLIAM FREDERICK DURAND.

We shall undertake in this chapter only a few hints regarding the more common operations involved in the overhauling, adjustment and repair of marine machinery.

Cylinders.—First, in the main engine, the cylinder covers must be removed at proper intervals, and attention given to the condition of the wearing surfaces and of the piston springs. The troubles most liable to be found are cutting and scoring of these surfaces, and derangement or breakage of the springs. The nuts of the follower studs and all other forms of screwed fastenings should also be examined, in order that any tendency toward loosening up or backing off may be noted and checked.

In order to test the tightness of the piston rings we may proceed as follows: Put the engine and links in such position that a little steam can be admitted on top of the piston and then open the bottom indicator cock. Then admit the steam, usually through the starting valve, and if it blows through the lower cock the piston is thus shown to be leaky. For a thorough test it will be well to try the leakage in both directions; that is, from top to bottom, as above, and similarly, from bottom to top.

Pin Joints and Bearings.—The various pin joints and cylindrical bearings will need attention according to the special circumstances of the case. The manner in which a joint or bearing has been working, both as to noise and temperature, will often serve as a guide to those which the most require attention.

Such bearings may simply require readjustment or refitting and adjustment as well. When the wear has been considerable, the liners or chock pieces between the brasses will need thinning, in order to reduce the clearance between the journal and the bearing to the proper amount. In order to measure the clearance under any given adjustment, a piece of lead wire is employed, of somewhat greater diameter than the clearance is to be. This wire is placed on the journal and the cap is screwed down hard, thus compressing it between the journal and the brass. The cap is then removed, and from the resulting thickness of the wire the clearance at any point between the journal and the brass may be readily measured. Such an operation is called taking a lead. Several leads, if desired, may be taken at once from a bearing, and will thus serve to map out quite satisfactorily the distribution of clearance, and thus to show when the proper adjustment has been made. The proper amount of clearance in any given case is somewhat a matter of judgment, and will, of course, vary with the size of the journal. In ordinary cases it may be made about .002 of the diameter.

If time is limited the adjustment may be effected without the taking of leads, as follows: The chock pieces or liners are taken out and the nuts are tightened up till the brasses bear full on the journal. Their positions are then marked, and they are then backed off an amount determined by judgment or experience with the particular circumstances of the case, and the liners are stripped to fit this adjustment. While this method is not as satisfactory as with leads, it is much quicker, and with experience good results may be obtained.

In connection with the marking of the nuts it may be recommended as a good plan to mark permanently with a line and a numeral 1, 2, 3, 4, 5, 6, the faces of all the large nuts likely to be used in making adjustments. An adjacent reference line on the bolt or on the metal of the bearing caps will then furnish means for making a record of each adjustment, or if no permanent record is desired, such means will greatly facilitate making the adjustment in any given case.

Cross Head Guides.—The main guides and cross head slides must also receive attention, both as regards cutting or uneven wear, and as regards the question of adjustment. The result of wear is to throw a cross-breaking stress on the piston rod at each stroke, as the cross head is forced over by the oblique action of the connecting rod to a bearing on the guides. Care must therefore be taken that when the engine is turned without a load, the guide surface remains in full contact with the face of the slide, and therefore in a condition to support and guide the lower end of the piston rod in a path consistent with the movement of the rod in the axis of the cylinder. If this condition is not fulfilled the necessary adjustments must be made in the manner best suited to the structural arrangements of the case in hand.

Cross Head Marks.—In connection with the adjustment of the moving parts of the engine it is well to have a mark on the cross head and corresponding marks on the guide, showing the extreme positions of the piston when in contact with the cylinder heads, top and bottom; also two marks placed slightly within the latter and showing the ends of the natural stroke, and a mark placed midway between the two latter, showing the location of the piston when in midstroke. The distance from the extreme marks to those showing the ends of the stroke, shows the amount of clearance proper between the piston and the cylinder heads when the former is at the ends of the stroke.

This will vary with the size of the engine and character of the workmanship, but it is usually found between 1-4 and 5-8 or 3-4 in., being a little more at the bottom than at the top, to allow for the general tendency of the parts to lower rather than to rise through the effect of wear.

To determine these points a convenient reference mark is first placed on the cross head. The connecting rod may then be disconnected and the parts hoisted up as far as they will go, or until there is contact between piston and head. A mark is then made on the guide corresponding to that on the cross head. The parts are then lowered down as far as they will go, or until there is contact between the piston and the lower head, and another mark is made on the guide corresponding to that on the cross head. The distance between these is then taken, and from it is subtracted the length of stroke. The remainder is then divided between the two clearances, top and bottom. Midway between the two inner points a point may be placed to indicate the location for mid or half stroke.

Thus, if the stroke is 36 in. and the distance found as above is 37 in., the 1 inch difference is to be divided between the two clearances, giving to the upper, say, 7-16, and to the lower 9-16 in. These differences are

then laid off within the outside marks, and the points thus given will serve at any time as a guide for the adjustment regarding clearance proper, while the movement of the piston may be readily brought to conform to these limits by suitable adjustment of the liners or chock pieces in the joints and bearings of the connecting rod and crank shaft. The 36 in. may then be divided equally and the mark placed to show mid stroke, such a point being sometimes of use in connection with the setting of the valve.

Lining Up.—An important feature, both of the original setting up of machinery and of its overhauling and adjustment, is the determination or correction of the alignment of the various moving parts. It is clear, of course, what the condition of proper alignment is. For a marine engine it may be briefly stated as follows:

(1) The centers or axes of the main pillow block bearings should all be in one straight line, which will coincide with the crank shaft axis, and which we will take as a standard or line of reference.

(2) The axes or center lines of the cylinders should all be in the same vertical plane containing the center line of (1), and they must also be at right angles to this line.

(3) The same vertical plane should also contain the axes or center lines of all the cross head pins.

(4) The axes or center lines of the crank pins or crank pin bearings in the connecting rods must all be parallel to the center line in (1).

(5) The surfaces of the main guides must be parallel to the plane in (2).

(6) The line shaft must be in line with itself, and unless a flexible coupling is provided between this and the crank shaft it must also be in line with the crank shaft, as determined by the line in (1).

The same general principles, of course, control the alignment of the valve gear and the various other moving parts, such as the starting, handling and drain gear, attached pumps, etc., but into these we need not go in further detail.

The implements used in establishing the relation between these various lines and planes will naturally vary with the circumstances, but are usually found among the following:

The level, plumb line and square.

The straight edge.

The stretched wire or cord.

Provision for using a line of sight.

A straight line, such as that for a line of shafting, may be determined by either of the latter. The sag in a piano wire of known size and length and stretched with a known weight over a pulley is a matter which may be found by a computation, into which we cannot enter here, or, better still, it may be determined in the open air by the aid of a surveying instrument with the usual cross hairs. A table giving the sag at various points between the ends for known lengths and for a known stretching weight will then give a ready means of establishing a straight line on board ship, by stretching the wire under the same conditions, and then setting upward at the various points the amount of the sag. A series of levels may thus be found which will give a true, straight line within the limit of the error in measurement.

When a line of sight is used the following method may be employed. A board is fitted to the bearings at the extreme ends of the line to be run, a hole of some considerable size being made in the board at about the center. This hole is then covered with a piece of thin sheet metal having a small hole, say, 1-16 to 1-8 in. in diameter. These sheets of metal are adjusted by measurement until the small hole, as accurately as may be, is brought to the center of the bearing. Similar boards are then prepared for the other bearings or points at which it is desired to establish the line. A light is then placed at one end beyond the further hole, and the eye at the other end. An assistant then adjusts the intermediate pieces of sheet metal until the light reaches the eye through the entire series of holes. The centers of these holes will then serve to establish a series of levels which may be marked on the pedestals, bulkheads or other convenient points, and which will serve to establish the line as desired.

In lining up and adjusting the engine itself so that the various conditions (1)-(5) above are fulfilled, very much will depend on the accuracy and care with which the various parts have been machined in the shops. The gaps in the bed plate, which receive the main bearing boxes, should be planed out so that they are all in line. This is a matter which may be tested by a straight edge, or by measurements from a stretched wire. If the bottom brasses are then adjusted, all to the same thickness, they will evidently support the crank shaft in line. This may also be further tested by reference to a line of levels, each of which is obtained by measuring the same distance upward from the bottom of each gap, and locating on the bed plate at any convenient point the level thus determined. This adjustment, it may be noted, will bring the axis of the crank shaft parallel with the bottom of the gaps.

Passing now to the columns, the seatings for their feet should have been planed at the same time as the gaps. This will bring the bottom of the feet in plane parallel with the bottom of the gaps, and hence parallel with the axis of the crank shaft. The columns and cylinders may now be erected and temporarily secured in place. The center line for each set of moving parts may be next determined as follows: A piece of board is placed across the top of the cylinder and secured at each end and over one or more stud bolts. Then, by careful measurement or the use of a beam compass, the center of the bore at the top of the cylinder is located on the board. A small hole is then bored at this point and a fine wire is passed through and attached to a little frame, which will allow a few inches of the wire to show above the board. The lower end of the wire is then located in the chank shaft axis by suitable measurement from the faces of the bed plate. The wire is then stretched between the two points, and the adjustment of the upper end verified by renewed measurement. If these parts come accurately to place we shall find that the wire will be truly central relative to the opening left in the lower head for the stuffing box, and hence it may be taken as the true center line for the cylinder as a whole. We shall also find the wire at a constant distance from the guide surface on the column, thus proving the latter parallel to the center line, as required by (5) above. We shall also find the wire at right angles to the crank shaft axis, as required by (2)

above, and, of course, in a general way, at right angles to the bed plate transversely.

Supposing these various conditions fulfilled for each center line separately, then we must see if they are all in the same fore and aft plane as referred to in (2) above. To examine this point we may try to look the wires "out of wind," as the expression is, by standing aft or forward and trying, by sighting fore and aft, to bring all the wires accurately behind the nearest one. If these various conditions, for each wire separately and for all collectively, are not fulfilled, then the necessary adjustments must be made until they are brought into the required relations, as above specified. As a further adjustment to be made at this time, a wire may be stretched fore and aft along or near the guide surfaces, and at the same horizontal distance from each vertical center line. This will serve to show whether the guide surfaces stand in the right direction fore and aft, and hence, whether the plane of each is parallel to the central plane defined in (2) above.

In setting up attached auxiliaries, such as air, circulating or feed pumps, the principles used will be similar to those already discussed, while the methods used will depend upon the particular circumstances of the case. If the seatings are located on the bed plate they will probably be planed at the same time as the main bearing gaps, and if the pump bases are faced at the same time they are bored, their axes will come at right angles to the seatings, and hence parallel to the axes of the main cylinders, and thus properly in line.

In order to test the line of the cross head pins the connecting rod may be hung from the upper end and allowed to swing partially free at the bottom. Then, by turning the engine into various positions in the revolution and measuring the fore and aft clearance between the crank webs and the faces of the lower end of the rod when thus relieved of constraint, the accuracy of the adjustment can be determined. This operation may be carried out in the following manner: Assuming that it is desired to test the adjustment in the case of an engine completely set up, the cap on the lower end of the connecting rod is removed and the cross head is shored up in any convenient manner. The engine is then turned slightly by hydraulic jack or turning engine in such direction as to carry the crank pin away from the rod and thus leave the latter free in a fore and aft direction, so far as direct contact with the pin is concerned. Measurements are then taken, and the engine is next moved around so as to bring the pin against its bearing again, and then on to a new position. Here the cross head is again shored, the pin backed off, measurements taken as before, and so on. In this way the piston, cross head and connecting rod are carried around by resting on the crank pin, and then in each position the connecting rod is freed by shoring the cross head and backing off the crank pin. In case the clearance between the crank pin brass and the faces of the webs is too small to allow a possible irregularity of movement to show itself, the regular brass may be taken out and a dummy brass or wooden block, with sufficient clearance for all possible motion, may be fitted in its place.

In locating a line shaft, a wire or line of sight may be used in the general manner above described. After locating the center of the stern tube at the stern post, the line is run to the after end of the crank shaft or on through to the forward end, as may be desired, such point being located by measurement according to the drawings of the ship, engine seating and bed plate.

In twin screw ships the centers at the after struts are located by measuring at the proper height the necessary distance outward from the center line of the stern post, at the same time squaring from this center line so as to bring both centers at the same height above the keel. The two lines are then set at the forward end at equal distances from the keel at the proper height, in accordance with the drawings. In most cases the shafts are not parallel with the keel, either in a vertical or horizontal direction, usually inclining outward from forward aft and either upward or downward, according to the size of the ship and other circumstances of the case.

In the examination of the adjustment of machinery which has been already in operation, as in the routine care of marine engines, it is not to be supposed that the preceding operations in all their details will be necessary. Judgment must be used, having in view the particular points to be examined, and the best means of effecting such examination in accordance with the general principles above discussed.

Thus the fairness of the line shafting must be tested occasionally, lest, as time goes on, wear in the bearings or changes in the structure of the ship may throw it seriously out of line. For this purpose the following method may be used: Three or more lathes or battens are provided with a straight edge on one side. These are then placed across the shaft on the upper side, as nearly horizontal as judgment may indicate, being located at successive points along the line of shafting to be examined. A line of sight is then taken along the projecting lower edges of the battens and by adjustment they are brought parallel to each other. Then, if they can all be brought into one line the shaft itself is in line. If not, the shaft is out of line in the vertical direction, and, by blocking or other similar adjustment, until the battens are all brought into one line the amount by which the shaft is out at one point relative to two others is readily determined.

In a similar manner the line in the horizontal direction may be tested by holding the battens vertical against the side of the shafting. This method presupposes, of course, that the shafting throughout the part tested is all of the same size.

Instead of placing the battens on the shafting they may be placed on the couplings quite as well, supposing, of course, that the latter are also of the same size.

Another test which is sometimes used consists in slacking the coupling bolts at a coupling near which it is suspected that the shaft is not in line, and noting whether there is any tendency for the two parts of the coupling to open out on one side or another. Such an opening out then shows an unfairness in the line in one way or another, according to the side on which it appears.

Valve Gear.—In the routine examination of the valve gear the points to be looked for are wear and lost motion in the eccentrics and eccentric straps, or in the various pin joints and connections, and abrasion or uneven wear in the valve faces or seats. In the case of the eccentrics and straps and various pin joints, the wear may be taken up by the adjustments usually provided. Excessive or irregular wear in a flat slide valve or seat

may require either resurfacing or renewal, according to the circumstances of the case. With piston valves, especially if not fitted with rings, excessive wear in either valve or seat will mean a serious steam leak, and will usually call for new parts, either for valve or seat or both.

Condensers.—The chief troubles to be expected with condensers are as follows:

(1) Leakage about the tube ends through the packings from the salt water to the steam side.

(2) Corrosion and pitting of the tubes, resulting ultimately in the development of holes or the breaking of the tubes and similar leakage, as in (1).

(3) Fouling of the tubes with oil deposit on the condensing surface, thus decreasing the heat conductivity of the metal and the efficiency of condensation.

The condenser heads or bonnets must therefore be taken off from time to time and the condition of the tube ends and packings examined with reference to the matter of leakage and general condition. The question of leakage may, if desired, be examined by removing the heads and filling up the steam side with water, and then watching for leaks on the salt water side.

When provided with bonnets for the purpose, the steam side of the condenser must also be occasionally opened and the tubes and interior surfaces examined, with reference to grease coating and general condition. Where there may be any doubt as to the condition of the tubes in the interior, a few should be drawn when the heads or head bonnets are removed, and their condition determined.

So far as the accumulation of grease is concerned, the condenser may be cleaned by the use of hot soda or lye water, care being taken to wash it out thoroughly so as to remove any excess of the alkali. When soda is used for the boilers it is sometimes introduced into the condenser, there entering the feed water and then passing on to the boiler. It may be questioned, however, whether this is the best plan, as accumulations of grease only partly converted to soap may thus be carried into the boiler, there giving trouble, as already referred to under that head.

Pumps.—The chief troubles to be expected in the operation of the various forms of pumps found on shipboard are as follows:

(1) In the water end the plunger rings or packing or the barrel may become worn, thus allowing considerable leakage or "slip," especially under high pressure, as in boiler feed pumps.

(2) The water valves, either inflow or delivery, may become worn or deranged, and thus fail to hold the water as they should, so preventing the proper operation of the pump.

(3) In the steam end the piston rings or cylinder barrel may become worn, allowing steam to blow from one side to the other and decreasing the effective steam load on the piston.

(4) The main steam valve or more often some part of the auxiliary steam operating gear may become worn or deranged so that the pump can no longer properly operate under steam.

These various troubles must be guarded against by periodical examination of the points mentioned with a view to wear or derangement of any kind whatever.

With air pumps, especially those attached to a main engine, where the number of strokes is usually greater than with the independent pump, the valves sometimes give trouble by severe pounding against their seats and guards. This is due to their inertia, and is likely to be more severe as the valves are heavier and have more lift. Light metal valves of sufficient number and size to allow of moderate lift are therefore to be preferred for all such purposes.

QUERIES AND ANSWERS.

Q.—1. How many kinds of electric currents are there? 2. What is the difference between the electricity obtained from a dynamo and that from a battery? 3. What is an ampere? 4. What is the difference between an ampere and an ampere turn? A. B. C.

A.—(1) Electric currents are designated as continuous, or direct; as alternating; as pulsating, and as interrupted. A continuous current flows continuously in the same direction; an alternating current flows in opposite directions alternately; a pulsating current flows continuously in the same direction, but increases and decreases in strength, or pulsates; an interrupted current is made up of a number of short current impulses following one after another, it may be compared to a stream of drops of water.

(2) There is no difference between the electricity obtained from a dynamo and that from a battery, or that from any other source, except in the strength of the current, and the electrical pressure or voltage. Battery currents are weak and of low voltage, ranging between about one-half of a volt, and two volts. The strength is seldom more than one or two amperes, and more often only a few hundredths of an ampere. The current of a dynamo may have a voltage as high as 2,000 or more volts, and is seldom lower than 25 volts, and the strength of the current may be anywhere from 5 to 1,000 or more amperes.

(3) The ampere is the unit of measurement by means of which the strength of an electric current is determined, and it is that amount of current that will flow through a conductor if the resistance is one ohm and the pressure is one volt.

(4) The ampere turn is a unit used for measuring the magnetizing force of coils wound around magnets, and is equal to one ampere of current passing once around the coil. For example, if we have a magnet upon which a coil is wound containing one hundred turns of wire, then if a current of one ampere passes through the wire, the total ampere turns of the coil will be 100. If the current strength is five amperes, the ampere turns will be 500. To obtain the ampere turns the number of turns of wire in the coil is multiplied by the number of amperes of current flowing through the wire.

Q.—How can one decide when a storage battery is charged to the proper point? What would be the effect if it were charged beyond this point? Is there any way of preventing the eating away of the clothes by the acid from the cells?

A.—(1) When storage battery cells are being charged, bubbles of gas can be seen passing from the plates to the top of the liquid and escaping into the air. As the charging progresses these bubbles become more numerous, and when the full charge is received, the escaping gas becomes sufficient to make the liquid bubble up like boiling water; hence, it is generally said that as soon as the cells begin to boil the charging current should be cut off.

(2) The battery cannot be charged beyond this point and the principal effect of continuing the current would be to waste energy, as all the power thereafter applied would simply generate gas that would escape into the air never to come back; hence, it represents a total loss.

(3) The acid from the cells will destroy cotton goods, but it has little or no effect upon woolen goods; therefore, the best way to prevent destruction is to wear woolen clothes.

STEEL CAISSON.—The new steel caisson for the gate at the New York Navy Yard was launched from the yard of the Pusey & Jones Co., Wilmington, Del., recently. The caisson is 92 ft. over all and 20 ft. broad.